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# Agricultural Research and the Rural Poor

A Review of Social Science Analysis

by

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and
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## *Abstract*

This book reviews recent trends in social science analysis of agricultural research (SSAAR), identifying gaps in research and outlining areas of high potential payoff to future SSAAR. The authors review the major themes treated in the evolution of theory on the generation and diffusion of agricultural technology since the 1950s. They conclude from this review that there has been a preoccupation with studies of the transfer of technology and institutions from international agricultural research centres to national research and extension services. Researchers have neglected a broad range of issues affecting institutions — whether formal, informal, public, or private — that are involved in agricultural research and technology promotion.

The authors also construct a framework for setting research priorities. This framework includes historical, technological, and institutional dimensions. Examples in applying the framework are given and areas of high future payoff are identified. They include (1) methods for working directly with technology users and promoting research; (2) ways of stimulating feedback from users and drawing out implications for future research policy; (3) developing institutions for equitable use of common property resources; and (4) analyzing motivation and rewards within research services. The book concludes with a list of over 1 000 references classified by major theme.

## *Résumé*

Ce livre passe en revue les tendances récentes en analyse de la recherche agricole fondée sur les sciences sociales (ARASS), cernant les lacunes en matière de recherche et indiquant les domaines qui pourraient porter le plus de fruits dans les années à venir. Les auteurs examinent les principaux thèmes traités dans l'évolution de la théorie sur la création et la diffusion de la technologie agricole depuis les années 1950. Ils en concluent que les études ont surtout porté sur le transfert de technologies et d'institutions des centres internationaux de recherche agricole aux services nationaux de recherche et de vulgarisation. Les chercheurs ont négligé toute une gamme de questions touchant les institutions — officielles ou non, publiques ou privées — qui se consacrent à la recherche agricole et ont pour objet de promouvoir la technologie.

Les auteurs élaborent également un cadre de travail, comportant des dimensions historiques, technologiques et institutionnelles, pour l'établissement de priorités dans le domaine de la recherche. Ils donnent des exemples de l'application de ce cadre et indiquent les domaines dans lesquels les résultats s'annoncent les plus prometteurs, abordant notamment (1) des méthodes pour travailler directement avec les utilisateurs de la technologie et pour promouvoir la recherche; (2) des façons de favoriser l'obtention des réactions des utilisateurs et de tirer les implications qui s'imposent pour de futures politiques en matière de recherche; (3) l'essor des institutions d'une manière qui permette une utilisation équitable des ressources de propriété commune; et (4) l'analyse des motivations et des gratifications au sein des services de recherche. Plus de 1 000 références regroupées selon les principaux thèmes figurent à la fin du livre.

## *Resumen*

Este libro pasa revista a tendencias recientes del análisis de las ciencias sociales empleado en la investigación agrícola (ACSIA), identificando lagunas en

la investigación y señalando áreas que tengan el potencial de ofrecer resultados positivos en el campo del ACSIA. Los autores analizan los temas fundamentales tratados desde los años 1950 a lo largo del proceso evolutivo de la teoría relacionada con la generación y difusión de tecnología agrícola y llegan a la conclusión de que ha existido una preocupación por los estudios sobre transferencia de tecnología e instituciones, de centros internacionales de investigación agrícola a servicios nacionales de investigación y extensión. Los investigadores han descuidado una amplia gama de cuestiones que afectan a las instituciones — ya se trate de instituciones formales, informales, públicas o privadas — que participan en la investigación agrícola y en la promoción de la tecnología.

Además, con el fin de establecer las prioridades investigativas, los autores crean un marco de trabajo que incluye dimensiones históricas, tecnológicas e institucionales. Se dan ejemplos de aplicación del marco de trabajo y se identifican áreas que tengan gran potencial para dar resultados positivos en el futuro. Entre éstas se encuentran: (1) métodos para trabajar directamente con los usuarios de la tecnología y promover la investigación; (2) maneras de estimular a los usuarios para que expresen opiniones evaluativas sobre la tecnología utilizada y extraer conclusiones para futuras políticas investigativas; (3) desarrollar instituciones para el uso equitativo de recursos de propiedad común; y (4) analizar la motivación y premiación dentro de los servicios investigativos. El libro concluye con una lista de más de 1 000 referencias clasificadas por temas principales.

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# *Foreword*

"Politics," the saying goes, "is far too important to be left to the politicians." In a similar vein, the underlying premise of this book is that agricultural research is far too important and complex to be left to the researchers, or at least to any one group of researchers.

Biggs and Farrington argue that agricultural research and promotion cannot be seen as neutral, technical activities; instead, they are "fundamentally integrated over time with political, economic, and institutional events." This recognition of the "social" nature of agricultural research has given rise to a large volume and wide variety of writings, which the authors call social science analysis of agricultural research (SSAAR). Such analysis, they argue, is important not only as an academic field of research but also as a tool to improve the effectiveness of agricultural technology development and diffusion.

Indeed, the authors claim that the demands on social science research are likely to increase in the near future, in response to the following factors:

- the increasing complexity of scientific research, which now demands the coordinated effort of many highly specialized disciplines;
- the complexity and diversity of farming conditions, particularly as research attention shifts away from large-scale, resource-intensive "Green Revolution" farming methods toward the problems of small-scale farming in rain-fed environments; and
- the increasing complexity of the objectives agricultural research is called on to satisfy, manifested most clearly in the current emphasis on long-term sustainability.

These trends increase the need for social science inputs into research planning and management, and, at the same time, make social science analysis all the more difficult.

This book grew out of an earlier review by Dr Stephen Biggs of the University of East Anglia (Biggs 1983a). Together with his colleague Dr John Farrington of the Overseas Development Institute, Dr Biggs has extended the original analysis to encompass writings produced since the early 1980s. The result is not simply an updating of the earlier work,

but rather a more fundamental reassessment, accounting for the recent evolution of theory, practice, and the problem area itself.

At the heart of this book is an attempt to organize and, where possible, synthesize the various social science perspectives on agricultural research; as a result, it should appeal in particular to those less familiar with the field, as a "road map" to a large and constantly expanding literature. At the same time, the book is not a mere catalogue of past research. The authors offer a critical account of the development of the field, stressing not only its accomplishments but also its shortcomings — most notably the slow pace at which research has moved away from stylized theory toward a recognition of the institutional and political factors that affect both the conduct of agricultural research and the translation of research results into farming practices. This analysis, and the authors' concrete suggestions regarding future priorities for SSAAR, should be of interest not only to students of the field but also to practitioners from a wide variety of disciplinary backgrounds.

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# *Preface*

The need we felt to produce a book of this kind crystallized slowly at first, but then with increasing intensity, over two decades of research, teaching, and consultancy. It marks growing dissatisfaction with restrictive views of what constitutes innovation and of how social scientists can contribute to generating, developing, and spreading improved technologies.

Some recent writings recognize that innovation is a complex process to which many actors in different roles contribute. Recognizing that per-hectare yield increases are a highly imperfect objective for innovation, such writings stress the need for attention to noncultivated biomass, to the long-term sustainability of the resource base, and to distributional issues. However, much of the literature remains dominated by narrow definitions of research and by narrowly hierarchical views of technology generation and transfer. Implicit preeminence is invariably granted to international institutes, placing national research and extension services in a secondary role and, in many cases, offering no analysis at all of those efforts located outside the public sector. Much of the activity of national and international research centres, and of funding agencies, is characterized by similarly narrow definitions and preoccupations.

At a different level, this book marks dissatisfaction with the closed circle of cross-citation characterizing much social science analysis of agricultural research (SSAAR). Citing the most easily accessible references poses two risks: first, overvaluing the contribution of those having the facilities and resources to circulate their work widely and ensure that it enters international abstracting services and, second, undervaluing the efforts of practitioners who either lack the resources for systematic publication or regard it as a low priority.

To unearth obscure publications or experiences is difficult and time consuming; we acknowledge that the more than 1 000 references presented here is no more than a fraction of the work that merits wider circulation. However, the need to attribute ideas, as far as possible, to their original sources, to accept as valid the innovations developed in isolation from the academic mainstream, and to learn from these more about the nature of innovation made it imperative to give greater attention to lesser known work than is given in most reviews of this kind.

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Chapter 2 of this book is a revised and extended version of a literature review conducted by Stephen Biggs and Edward Clay (1988). We thank the Gower Publishing Company for their permission to use this material and gratefully acknowledge the contribution of Edward Clay to this book. The discussion in Chapter 3 concerning farmer participation in on-farm client-oriented research draws upon Biggs (1989b). We appreciate the cooperation of the International Service for National Agricultural Research (ISNAR), which allows and encourages its research papers to be used in this way.

The authors are particularly grateful to John Graham of IDRC, Stuart Kean, and two anonymous reviewers for their detailed comments and helpful suggestions on earlier versions of the manuscript. We also thank Kate Cumberland, at ODI, who did an excellent job of typing what was at times a highly fragmented manuscript.

# Chapter 1

# Introduction

## Conceptual Background

This book takes a wider view of science than that normally found in discussions of agricultural research. It represents an attempt to introduce broader perspectives at three levels.

First, we reject narrow definitions of agriculture and agricultural research. Our concern extends beyond the production of annual or perennial crops and livestock to include interactions among the systems and subsystems to which these production activities belong. In many areas, interactions with noncultivated species, e.g., as fodder, are important and have to be considered. Our concern is not only with the production of crops or livestock but also with linkages to those sectors or activities concerned, on the one hand, with processing and marketing and, on the other hand, with the production and supply of inputs.

On a different dimension, but underlying our definition of agriculture and agricultural research, is the interrelationship between productive activities and the longer term sustainability of the resource base. Performance criteria such as yields per hectare fail to distinguish whether a cropping activity is, over the longer term, depleting the productive resource base or, through judicious soil and water conservation, maintaining, or even enhancing, long-term productivity. These considerations take us into the realm of nonmarketed inputs and outputs.

"Agriculture" is therefore defined widely enough here to embrace both the interaction between cultivated and noncultivated components of the macrosystem and the sustainability of cultivated systems over time. Research in support of agriculture in this wider sense will seek to draw on ideas and approaches developed in several branches of science.

Second, we reject the view that agricultural research, if left to market forces, will deliver a stream of innovations that respond to factor prices and endowments in an economically efficient manner. Markets of this type are highly imperfect, and specific interventions have to be made to ensure that at least some of the needs of poorer groups, often seeking livelihoods in unreliably rainfed areas, are addressed by public-sector research and extension. Our approach is, therefore, concerned with issues of both production and distribution. It is normative in that it

outlines *why* at least some research resources should be allocated to poor rural dwellers and *what* needs to be done to obtain best value from these resources.

Third, we take a less structured view of the processes of technology development than the hierarchical pattern that has tended to dominate thinking and practice among many national and international research services and funding agencies. To present a slightly stylized image, the "hierarchy" has international agricultural research centres (IARCs)[1] and other regional or commodity-oriented centres at its apex. These centres develop new research methods and the building blocks of new technology through fundamental research. Results are then passed down to national centres for adaptation to local environments and then for dissemination to farmers through extension services. Science and scientists are seen as politically neutral, and little indication is given of differences in philosophy and approach among international centres or of the conflicts within or among them that have accompanied efforts to move their agenda in one direction or another. In practice, changes to science policy and to the structure or management of institutions are often critically important in determining the development or adoption of new ideas, practices, or hardware. Our concern is with innovation in this wide sense and with the multiplicity of actors who contribute to it public-sector research and extension centres, nongovernmental organizations (NGOs), farmers' organizations, and individuals, traders, and local authorities.

International institutes have played, and will continue to play, a key role in defined spheres — certain technologies are much more cost-effectively developed at the central than at the local level. However, undue emphasis on the achievements and potential of international institutes runs three risks:

- pressing them into spheres of research in which they have no advantage;
- ignoring spheres in which other types of institutes have a comparative advantage in technology development; and
- distracting attention from the types of research support and research methods that other institutes require if they are to be more effective.

Changes to the political, social and institutional context in which new technology is implemented are often highly innovative. However, they remain largely unanalyzed by models in which relative factor prices "induce" new technology from research (Hayami and Ruttan 1971) or induce changes in the number and type of (usually) public-sector institutions involved (Binswanger and Ruttan 1978).

[1] The 13 international centres affiliated to the Consultative Group on International Agricultural Research (CGIAR), unless stated otherwise.

Overemphasis in the Ruttan tradition[2] on public-sector institutions has led to an undervaluation of the role of many other types of agencies in formal or informal experimentation. These include technology users themselves, NGOs (which are now pursuing an innovative agenda at the international as well as the local level), and a host of local-level membership organizations (e.g., farmers' associations), extension services, and local government bodies. This book constructs an analytical framework embracing this multiplicity of institutional types, indicating where the bulk of social science analysis of agricultural research (SSAAR) has been focused and allowing decisions on future priorities for SSAAR to be related to the role of each and to interactions among them.

The main argument of this book is that agricultural research and technology-promotion activities are always fundamentally integrated over time with political, economic, and institutional events. There is not, on the one hand, a neutral, apolitical research and development (R & D) system that is steadily pushing forward the frontiers of academic knowledge and increasing productivity, and, on the other hand, the real world where political, economic, and institutional forces determine how scientific knowledge is used. The two are continuously and inextricably interwoven. To pull them apart leads to situations where policies and programs designed to achieve one set of objectives result in very different outcomes.

In practice, decisions taken in science are based not only on objectively scientific criteria but also on political considerations. The outcomes of such decisions contain a similar mixture. Allocations of resources to research tend to be determined by the predominance of one set of actors' views over those of others. A primary function of social science is to clarify the political, intertemporal, and income-distributional implications of the alternatives that decision-makers face.

## *Historical Context*

During the last two decades, there has been a rapid expansion in research on food crops in national and international centres. This has been accompanied by new institutional forms: much of the international research has been funded through the Consultative Group on International Agricultural Research (CGIAR) (Baum 1986). By as early as 1976, an experienced observer (Dalrymple 1979) estimated that one-third of the area under wheat and rice in developing countries had been sown with improved genetic material from either the International

[2] The work of Pray (1983) and Evenson et al. (1987) within this tradition focuses on the private commercial sector; but, as we argue in the body of this book, the objectives of this sector differ from those of other types of institute, and the agenda for social science analysis in agricultural research (SSAAR) relating to these will be correspondingly different.

Rice Research Institute (IRRI), established in 1961, or from the Mexican Wheat Research Programme, part of which was transformed into the International Centre for Maize and Wheat Improvement (CIMMYT) in 1964.

Green Revolution research has brought benefits both to those producing improved varieties and, through lower prices, to urban consumers. However, the spread of high-yielding varieties (HYVs) has been restricted largely to areas of better agroclimatic and infrastructural conditions; the situation of the majority of rural poor, in many countries, has continued to deteriorate. Mellor (1988) argues that poverty is predominantly a rural phenomenon and occurs in roughly equal proportions in areas of high and low agricultural potential (Table 1). The causes of rural poverty are therefore as much issues of wealth, employment, and income distribution as of regional economic potential. This situation is well illustrated by changes that have occurred in India where the technology of the Green Revolution helped the country to turn a food deficit in the 1960s and early 1970s into a food grain "surplus" in the late 1970s and 1980s. However, despite national food surpluses, it was estimated that the percentage of the rural population that had an intake of calories below the minimum poverty level and had increased from 32 to 49% between 1960/61 and 1983 (Dandekar 1986).

Many lessons have been learned from this seeming paradox between the spread of HYVs and the continuing prevalence of poverty. Three of the most important of these are as follows:

- The generation and diffusion of technologies is a complex and difficult process, particularly for unfavourable areas and for resource poor farmers and labourers.

- No amount of research on improving appropriate technologies can

Table 1. Distribution of poverty between rural and urban areas, and between areas of high and low agricultural potential (AP) in 1990 (millions of people).

| | Urban areas | Rural areas | High AP | Low AP |
|---|---|---|---|---|
| Africa | 14 | 123 | 61 | 62 |
| South Asia | 70 | 280 | 140 | 140 |
| East Asia | 5 | 26 | 6 | 20 |
| China | NA | 76 | 26 | 50 |
| Latin America | 29 | 43 | 11 | 32 |

Note: All values are tentative and should be seen as merely indicative. NA, data not available.
Source: Mellor (1988).

substitute for institutional reforms in such areas as education, credit, and land tenure.

- Greater attention needs to be given to socioeconomic analysis in agricultural research.

## *Purpose*

This book aims to categorize and review social science studies of technical change in agriculture, assess the strengths and weaknesses of these studies, identify gaps, and suggest work that might be encouraged in the future. The review is intended for agricultural scientists, research planners, and policymakers. It is being prepared at a time when publicly funded services in many parts of the world are coming under increasing pressure to be cut back or "privatized." There are, therefore, increasing demands on social scientists to identify what the future role of public-sector institutions in agricultural research is likely to be in relation to private commercial and voluntary agencies and what priorities are likely to emerge in each.

This book does not explicitly discuss welfare economics; its underlying objective is to identify how agricultural research might contribute to increased net social welfare. This involves explicit consideration of issues in both production and distribution. The role of private-sector research in increasing production through its response to the profit motive is acknowledged, but the public and voluntary sectors have to address issues of both production and distribution. Their role is, therefore, more complex and is given the bulk of attention in this book. Recurring themes in this context include the division of research resources among technologies intended to benefit rich or poor consumers and rich or poor producers. The large numbers of low-income producers working in difficult and often ecologically fragile environments, the complexities of developing and disseminating technologies for them, and the lack of success there of conventional approaches to research and extension combine, in our view, to justify the substantial attention that the book gives to these issues.

Within this broad context, three particular shortcomings in the role to date of SSAAR prompt this review.

First, social scientists and applied natural scientists have often analyzed agricultural research policy with minimum reference to each other's approaches. We find, on the one hand, many agricultural research institutions in which social scientists are not effectively involved in identifying priorities for agricultural technology development and, in some cases, are not even participating in research programs. On the other hand, social scientists study the impact of Green Revolution technologies or work in other areas of natural science with only a minimum of contact with, or knowledge about, agriculture or agricultural research institutions and processes. This has contributed to misunderstandings such as the inadequate interpretation of the role

of social scientists in certain reviews of agricultural research (e.g., Simmonds 1985) and the overstating by some social scientists of the importance of their discipline in, for example, farming systems research.

There are, however, instances in which social and natural scientists have made serious efforts to understand their respective roles. The planning conferences for the social sciences held at the International Potato Center (CIP) in Lima, Peru, in 1981 and 1987 are examples. The search for complementarity among disciplines is reflected in many of CIP's publications. One goal of this review is to improve mutual understanding of the roles of social and natural scientists in agricultural technology development.

Second, the performance of SSAAR has been patchy. Successes have been achieved, but there are numerous cases in which important issues have been missed or undue attention has been given to repetitious or unproductive areas of research. This review analyzes in some depth why SSAAR has been unproductive in some areas and what can be done to enhance its productivity for the future.

This task is complex. For instance, difficulties now arising with the cultivation of Green Revolution varieties of wheat, rice, and maize (e.g., vulnerability to pest attack, low palatability, poor storage and processing characteristics) are being referred to as "second-generation" problems, implying that they could not have been predicted. There is evidence, however, that more careful collaborative work between social and natural scientists could, in the early stages of research, have identified at least some of the problems that have subsequently emerged. What is equally important is that decisions such as opting for one type of plant-breeding strategy over another resulted from policy decisions that were influenced by *one* group of social and natural scientists representing *one* set of theories and advice (Hopper 1978; Rudra 1987). To refer to resultant difficulties as "second generation" evades a fundamental issue: agricultural technology development is always taking place in a political and institutional context. There are always likely to be conflicts between different theories of science and the views of different groups of scientists. The political setting has a major effect on science policy. A major purpose of this book is to stimulate awareness among social and natural scientists of the context in which they work and of the biases that may result.

Third, partly through the influence of social scientists, some research centres, particularly at the international level, are now promoting "innovative" procedures, which, in fact, have long been standard practice and whose application to developing-country agriculture was, in some cases, pioneered by developing-country scientists. For example, with support of the Food and Agriculture Organization of the United Nations (FAO), plant breeders and agronomists in East Pakistan (now Bangladesh) were setting up on-farm trials under representative local growing conditions as early as 1951 (East Pakistan 1967). Ironically, this well-conceived multilocational program, which had many of the features of the "new" on-farm research of the 1970s and 1980s, was

disregarded in the early 1970s when a group of international experts recommended that the new Bangladesh Rice Research Institute (BRRI) should emphasize trials in a special project area adjacent to the central experiment station, which was atypical of wider conditions (Freeman et al. 1974).

In many other cases, researchers simply mobilized funds and other resources to implement what they thought were suitable solutions; documentation of their ideas often does not exist or is only in unpublished form. Some of these studies are mentioned in this review — although these reports may only be a single copy on a dusty shelf, they are a healthy reminder that at least as many relevant and feasible ideas for the direction, content, and assessment of agricultural research systems come from the work of local scientists, cultivators, and other people in rural areas of developing countries, as from Western and international sources, or from intellectual innovations discussed in international publications. To ignore them is not only unethical but also diverts SSAAR attention away from valid questions of how complementarities between the various actors might most productively develop over time.

The second and third examples quoted here illustrate how special interest groups of scientists, politicians, or farmers can dominate priority setting and resource allocation at a given point in time. It is a major thesis of this book that the understanding of issues of control, organization, and management of agricultural research is relatively more important in many situations than a lack of knowledge of scientific principles and survey methods, or a lack of research equipment and other physical inputs. The application of social science analysis to agricultural research is a principal means of identifying these issues of control and management.

From its analysis of issues of this kind, this review seeks to identify the priority areas for SSAAR in the future, and the methods by which such priorities might be addressed. These are treated in three broad categories:

- theoretical and conceptual development,
- analysis of interactions among institutions of different types, and
- analysis of work within such institutions as public-sector research services, research institutes, and individual programs.

SSAAR in these categories (particularly the first two) tends to be "independently" instigated by social scientists directly or in response to broad policy initiatives. The United Nations Research Institute for Social Development (UNRISD) study on the social and economic implications of the Green Revolution is a major example of this type of SSAAR (Pearse 1980). In the third category, social scientists generally report to research managers, many of whom have a natural science background. The question of how research managers might best "direct" social scientists is, therefore, an important practical issue; it recurs throughout the book.

## *Methodology and Structure*

The preceding discussion of "independent" and "directed" SSAAR indicated that this review covers a wider area than the collaborative work between social and natural scientists within projects and programs. Such directed work includes the partial-budgeting analysis of results from on-farm trials and analysis of their potential (CIMMYT 1988). A recent study of the impact of the IARCs (Anderson et al. 1987) applies this approach on a broad scale. Although monitoring and evaluation is becoming widely accepted in many countries, some — even those with long-established research programs such as India — remain weak in this respect (Acharya 1986; Appa Rao 1987). The on-farm, client-oriented research program (OFCOR) of the International Service for National Agricultural Research (ISNAR) and "linkages" studies provide numerous instances of such weaknesses. An important function of this review remains, therefore, to indicate the types of SSAAR that can usefully be undertaken in close collaboration with natural scientists at project and program levels.

Earlier classifications and reviews of directed work of this kind and of work at the policy or conceptual level, independently initiated by social scientists, are summarized in Chapter 2. However, this overview is too restrictive for the broader objectives of the study: it allows an historical classification of SSAAR by major category, showing where the work has occurred, in what volume, and with what success. It offers little to help in identifying gaps, and its essentially historical character sheds no light on the areas likely to require SSAAR in the future.

An underlying premise of this book is that a classification can be devised that is more informative about worthwhile future directions for SSAAR than a simple historical breakdown by major thematic area. Agricultural research does not take place in an institutional or political vacuum. A prerequisite for such a classification is, therefore, an understanding of the principal factors explaining the *dynamics* of agricultural research in terms of, for example,

- the types of technology being generated,
- the types of institutions being developed and promoted,
- the processes and institutions involved, and
- the factors influencing the flow of public- and private-sector funds into research.

Only after an adequate framework is established that classifies these processes and interactions will it be possible to probe the focus and role of SSAAR more deeply. Those initiating and funding SSAAR can then be given systematic pointers toward priority areas for further work. The multiple source of innovation model (Biggs 1989a) is presented as a framework that can help define future research needs.

The first task in this process is to identify a reasoned set of criteria

on which a framework for classifying SSAAR can be based. Various criteria are discussed in Chapter 3; we take the view that both the activities *within* and *between* institutions requiring SSAAR must be made explicit. Institutions are then classified by type — public, commercial, or voluntary — and by level of operation — international, national, or subnational.

## *Scope and Terminology*

Several difficulties were encountered in preparing this review. First, the volume of SSAAR literature is vast. Our strategy has been to discuss pieces that we know are good illustrations of certain types of analysis, making no claim of comprehensiveness. The references are classified by major thematic grouping in Appendix 1.

Second, there are many definitions of agricultural research. These range from those narrowly focusing on the "basic" or "fundamental" to those including local-level modifications to technology. Our definition leans toward the all-embracing. In principle, we prefer a concept and definition that is broad, such as "technology development"; however, the frequency with which we use the descriptor requires brevity, so we use "research" in its broad definition.

We are well aware that this review does not do justice to the literature published in languages other than English. Also, we did not attempt to achieve comprehensive coverage for individual countries. However, as suggested in Chapter 4, we hope that this review will help research managers undertake their own reviews relevant to their particular situation and needs.

Third, there are the biases underlying such terms as "second-generation problems." There is a similar need for caution in interpreting other "loaded" terminology. This includes the notion that "advances" can be achieved in applied science through both "productivity increasing" and "maintenance" research. This begs the question of what criteria are used to define "advances." What is seen as an "advance" in applied science by one group may be seen as a regressive step or the promotion of unsustainable development by another. What constitutes an "advance" in any specific context is, in large measure, politically and institutionally defined. There are, of course, new issues arising that legitimately can be called "second-generation problems"; there are also some types of research that create what are universally recognized as advances. There remain, however, many occasions when these terms are used to defend the positions of specific scientific and political interest groups.

# *Chapter 2*

# *Generation and Diffusion of Agricultural Technology: the Evolution of Recent Theory*

This chapter provides some historical context to the development of SSAAR, seeking out the main areas of analysis that have preoccupied economists, sociologists, and anthropologists. It traces how their work has evolved in response to each other, and in relation to the principal policy changes in promoting agricultural research. This discussion largely draws on a chapter by Biggs and Clay (1988) in a book edited by Ahmed and Ruttan (1988).

During the colonial period, agricultural research in developing countries focused principally (but with important exceptions) on export and nonfood crops (Busch and Sachs 1981). With political independence, there was a move in practically all developing countries to establish national agricultural research and extension services. A parallel move took place to set up IARCs complementary to national services. This was premised largely on the view that research services in the North had taken a long period to evolve, and that developing-country services could produce results much more quickly if the following two conditions were fulfilled.

- They should adopt some of the institutional models developed in the North for technology generation.
- Some of the technologies available from elsewhere should be "transferred" to developing countries and, with a minimum of adaptive work, applied to their own agriculture.

Such technologies might originate either from agriculture in the North or from the international centres themselves.

Transfers of technology and of institutional models have not always achieved the desired results. Considerable controversy has been generated over their role in agricultural development, specifically in relation to the evolution of institutions and capabilities in developing countries. The literature in this area is inevitably very diverse. However, many themes can be traced during its evolution.

These different themes do not amount to a school of thought representing a consensus of theory and prescription. In fact, the

opposite is frequently the case. However, they do represent the preoccupations of different groups of writers. Economists, for example, tend to write more on the themes of factor endowments at a macro- (national or sectoral) or micro-level. Anthropologists and sociologists are more preoccupied with social relationships and transactions between socioeconomic groups in rural communities and rarely involve themselves in issues of planning or policy. Geographers and natural resource scientists are more often preoccupied with the spatial issues and with technological change in the context of environmental balances. The different thematic preoccupations across disciplines also typically imply different positions on, for instance, the macro- to micro-spectrum and different approaches to collecting and analyzing information.

What is interesting and important in this chapter is that, although some evolution of thought can be traced, writers preoccupied with one theme appear either to dismiss, by-pass, or misrepresent the preoccupations of writers on other themes. They are often unaware of the potential benefits of broadening their interests. One reason for this may be that different preoccupations relate to different ways of conceptualizing the organization of activity (by sector, by community, or by agroecological space).

Over the last three decades, SSAAR has evolved away from simplistic views that Western technology and institutional models can be implanted into developing countries, achieving the same kind of impact. There is now a much clearer recognition that more analysis and research is needed on the structure and organization of formal and informal research and extension institutions.

Six major themes appear to dominate the SSAAR literature: modernization, factor endowments, distribution and equity, interrelations between countries, environmental themes and ecological crisis, and research and extension institutions. Within each theme, we review the principal conceptual and empirical literature, highlighting particular contributions made by SSAAR and gaps that remain.

## *Modernization*

Thinking about the role of agricultural science in development was dominated until the mid-1970s by the concept of modernization. This implied the introduction of new, often "Western" technology and management practices, sometimes accompanied by changes in the size and structure of landholdings, with the intention of emulating patterns of agricultural development that had evolved in the North. Policy practices based unequivocally on this concept continue, notably at the extensive frontier of capitalist agriculture development (e.g., eastern Bolivia — Maxwell 1980) and in the application of socialist principles to tropical agriculture (e.g., Mozambique). The concept has been applied in modified form in many other developing countries.

In retrospect, there was no single model of modernization, but,

rather, a cluster of concepts that provided a vocabulary for modernization across many sectors of national economies. This vocabulary provided the analytical underpinning for the practice of scientists, governments of Third World countries emerging from European, American, and Japanese colonialism, and the multilateral and bilateral aid community. Among these key concepts, which subsequently became the focus of critical analysis, were

- the *dichotomy* of the modern and the traditional;
- the *transformation* of the traditional into the modern;
- *agricultural development* as the transformation that is measurable in agricultural product growth;
- *stages*: for many there were clearly demarcated stages on the road from the traditional to the modern — the notion of stages not only applied to the overall development process, but it was also an organizing concept for the transformation of activities in an institutional context; there is an underlying notion of inevitability and linearity in the transformation process;
- the *transfer* of technology, know-how, and institutional models as a key role in modernization, accelerating transformation; and
- the *diffusion* of improved ways of doing things through the adoption of new practices, including improved or new techniques in directly productive and research processes.

From these key concepts, the notion of *transfer* has been central to the process of transformation as it relates to agriculture (and other sectors) in two contexts: new and improved technology and institution building. In both of these contexts, however, the emphasis has been on "transferring in" technologies or institutions from situations in which they function well, rather than on strengthening and improving what already exists.

New and improved technology, seen to be the heart of development, requires more investment in formal research, whose designated role is to generate new technology or to adapt technology that is transferred from other countries. As regards institution building, it was assumed that a traditional, underdeveloped economy lacked the appropriate institutional forms that would facilitate, or even be a precondition for, rapid transformation. The supposed linearity of the development process implied that relevant institutional forms could be identified within the successfully modernizing countries and be *transferred* to other developing countries, facilitating their development.

Transfers of biological technology, sometimes haphazard, that broaden the genetic pool of a species have long been recognized as potentially the most important source of improvement in animal and plant types (Dalrymple 1986a). If gaps between traditional and modern practice in, for example, the use of specific genetic technologies can be identified, this offers opportunities to accelerate the process of

transformation by direct transfer. Such perceptions of the scope for agricultural technology transfer are well founded. However, adherents to modernizing theory constructed much more ambitious notions of transfer.

Although no uniform model of the transfer process has been developed, Ruttan's (1975a,b) typology suggests four main areas of interest:

- *material* transfer (chemical inputs, genetic material, etc.),
- cultivation *practices* (e.g., rice transplanting from Southeast to South Asia in the 1950s),
- *know-how* and fixed designs ("blueprints") for technology, institutions, or approaches to research, and
- transfer of technology-generation *capacity* through institution building and technical assistance.

The prospect of systematically directing the hitherto largely haphazard process of transfer is appealing. However, the emphasis placed on transfer by adherents of modernizing theory and the attempt to provide a typology of transfers have been problematic, as much of the more recent critical literature has demonstrated.

First, any discussion of transfers needs to be located precisely in the context of the recipient systems. The notion of transfer of technology embodied in genetic material or machines is unambiguous. However, the widespread assumption that such technologies will be adapted by *formal* developing-country research systems and disseminated among farmers ignores both the pervasive experimentation within the *informal* R & D system (i.e., among farmers and artisans) (Biggs and Clay 1981) and the important question of how compatible such technologies are with the opportunities and constraints faced by farmers. Such assumptions, therefore, underrate the importance of searching for types of technology and for means of sustaining and modifying them that are within the capacity of local formal and informal R & D systems. They also fail to recognize that communities and research systems are made up of different groups with varying degrees of influence on resource allocation, and that such interest groups tend to compete.

Second, transfer and diffusion are inherently centralist (Rogers 1983). The most striking manifestation of centralism was the establishment and early work of the IARCs. Their initial focus was on crop improvement in wheat, maize, and rice. This focus reflected the perception that there had been considerable advances in this area through agricultural research in the North and in East Asia. There were, therefore, possibilities for accelerated increases in land productivity in many developing countries. Centres were established to not only transfer and test material but also to develop new, adaptable technology that would be appropriate for widespread transfer and adoption. These centres established outreach programs to assist local

testing, and scientific work was organized around the improved material being developed.

This approach led to high levels of adoption, particularly of HYVs of wheat and rice; however, adoption occurred mainly in areas with favourable agroecological and infrastructural conditions (Dalrymple 1986a,b,c). SSAAR was slow to identify the inherent limitations of this approach; administrators were even slower in taking remedial action. It is now widely recognized that the centralist model suffers from

- an inability to cater to diverse agroecological conditions outside the range of those "targeted" (Evenson 1974; Farmer 1979; Pain 1986; Anderson et al. 1990),
- an insensitivity to feedback on the suitability of the technologies developed (Perrin and Winkelman 1976) (e.g., delays by IRRI in starting research on upland and deep-water rices — Barker 1981), and
- limited attention (until the establishment of ISNAR in the early 1980s) to the need to foster technology-generation capacity within developing countries.

What is striking about modernization theory and practice is the presumption that technology can be transferred from a unique economic, social, and political context with a minimal loss of its productivity-enhancing attributes. Regardless of whether it takes place only on developing-country research stations (as frequently remains the case) or under conditions faced by farmers, researchers must note the experience gained by farmers through their own experimentation if they are to assess accurately the prospects for technology adoption. However, one of the most pervasive criticisms of research systems constructed on the hierarchical, transfer-of-technology model is that they have given inadequate attention to feedback from farmers. Numerous examples emerge from two major studies by ISNAR: research–extension linkages and OFCOR. Furthermore, such systems have particular difficulty in accommodating recent moves toward direct participation by farmers in the research process (Farrington and Martin 1988).

The problems that arise are potentially much more complex when the objective is institutional transfer or reorganization to allow transfer. These issues are discussed in detail in a later section. An important criticism of models involving institutional transfer is that the consequences are invariably something other than what was intended (Hart 1961). For example, the United States' land-grant colleges (LGCs) are part of a complex, decentralized, highly successful system integrating training, research, and extension (Stavis 1979). However, the institutions established on this model have invariably proved to be centralist and elitist, whatever the developing-country context, i.e., quite unlike the original model in a fundamental sense (e.g., India — Brass 1982; Mexico — Fitzgerald 1981). This is perhaps because most institutional transfer of this type has been funded by development assistance, and these resources conventionally flow from government to

government. As a result, their intended objective is frequently modified to suit the interests of the State (Brass 1982). There is perhaps, therefore, a contradiction in using these resources to transfer decentralized institutional models.

What is strikingly absent from modernization theory or practice is any attempt to build on the alternative postulate of evolving institutional forms that are appropriate or relevant and, therefore, potentially different from the metropolitan models. The Chinese socialist models are an example of alternative, noncentralist institutional forms (Stavis 1978; Rogers 1983). However, these institutions are primarily concerned with production and social organization of production, rather than agricultural science.

In conclusion, the pace of implementation of "modernizing" approaches, whether focusing on the transfer of technologies or of institutions, has outstripped the evolution of balanced views by social scientists on the appropriateness and sustainability of particular types of transfer. Although attempts to transfer institutional forms, particularly in the public sector, have proven problematic, the transfer of certain types of technology has been quite successful. Examples include the transfer of genetic material from international to national centres (Dalrymple 1986a); transfers from public sector (or parastatal) agencies in developed countries to developing-country national research systems (e.g., Newcastle disease vaccine for poultry — Copland 1987); and transfers from the commercial sector in industrialized countries to commercial or public-sector agencies in developing countries (agromechanical and chemical technologies provide many examples). Recent examples have begun to emerge of the transfer of technologies through international NGO networks (Farrington and Biggs 1990), which generally (although not always — see Moris 1988) are more sensitive to local problems than public-sector networks.

The overall impression is that SSAAR focusing on the theory and practice of modernization has, with a few exceptions, been limited in scope and effectiveness. Social scientists have failed to address, at an early stage, the limitations of technology transfer. This has resulted in long delays in identifying and building upon the comparative advantages of the variety of actors involved in technology development — whether public-sector, commercial, or voluntary agencies, or the farmers themselves. As developing-country governments seek to promote the development of areas characterized by complex, diverse, and risk-prone agricultural conditions (Chambers et al. 1989), it is important to recognize that the public sector alone, no matter how well financed, will be unable to develop acceptable technology for the wide range of prevailing conditions.

In this context, it is essential to identify the relative strengths and weaknesses of local actors and devise modes of work on agricultural technology that allow these actors to complement each other and to draw on international research facilities. This requires substantial,

detailed effort by social and natural scientists at both national and subnational levels.

## *Factor Endowments*

Perhaps the most extensive SSAAR literature concerning technical change in agriculture is that dealing with the availability of, and markets for, factors of production (land, labour, capital, management), their prices, and choice of techniques. We portray these themes as a reaction to modernization theory: much of this literature came in response to the indiscriminate actions of transferring technology or methods of farming from one country to another, irrespective of local factor endowments, price levels, or other constraints. Perhaps most indiscriminate was the transfer of capital-intensive technologies to labour-abundant economies. SSAAR responded in various ways.

Schumacher (1973) promoted the philosophy of transferring and developing intermediate technology that was appropriate to local factor endowments. His philosophy underlies the many intermediate or appropriate technology movements that have focused on making available information on equipment or techniques potentially useful to small-scale rural producers or households.

Hayami and Ruttan's (1971) induced technical change model is an important contribution to the theory on technical change in agriculture. Drawing originally on comparative historical data from the United States and Japan, they illustrated that where factor prices appeared to reflect national factor scarcities, technology appropriate to those resource endowments was generated and used. In the United States, where labour was scarce and land and capital were relatively abundant, capital-intensive technology had been induced. In Japan, where land was scarce but labour was abundant, labour-intensive technology had been induced.

The theory has been further developed to encompass induced *institutional* change (Binswanger and Ruttan 1978). In Japan and the United States, the evolution and behaviour of research institutions is seen as a normal and *expected* response to meet the needs of producers by developing appropriate research programs.

Policy actions that follow from the induced innovation model focus on getting factor market prices (or surrogates for market prices) right so as to reflect relative factor scarcities. If this is done, then, according to the model, appropriate technologies (or institutions that produce them) will be induced into existence and will spread.

A third major theme of writers preoccupied with factor endowments has been the problem of the appropriateness of technology creation, development, and extension processes. For example, in a review of wheat and maize adoption studies, Perrin and Winkelmann (1976) found that it was not so much a matter of factor prices being "wrong" as

that technologies were generated and promoted that were inappropriate to farmers' factor endowments. This perception contributed to the development of "farming systems" principles and methods for understanding farmers' opportunities and constraints before technology is developed and extended (Byerlee et al. 1980).

A fourth type of research spurred by the patchy adoption of HYV rice is the use of ex-ante benefit–cost analysis for allocating research resources. Barker (1981) showed that the expected social returns to investments in research on rice varieties for rainfed conditions would be far higher than the returns in either extending irrigation facilities or in more research on rice varieties for irrigated conditions. This type of study helped to reorient rice research toward farmers' problems.

In summary, policy analysis and action derived from SSAAR analysis of factor endowments revolve around getting factor prices right and developing and extending knowledge about appropriate techniques. The great strength of this analysis is that these are crucial aspects in understanding processes of technological change in mixed and socialist economies. However, among the issues that have not been of central concern to this set of preoccupations but have proven to be central to increases in production and productivity are

- the reconciliation of short- and long-term factor prices,
- the analysis of commodity (as opposed to factor) prices and the impact of income distribution on effective demand,
- the effects of a skewed distribution of land and other resources on technology generation and diffusion, and
- the effects of factor market failure and imperfections and differential access to factor markets and public-sector services by different socioeconomic classes.

These issues make up some of the themes of distribution and the environment, which are discussed in the following sections.

## *Distribution and Equity*

As noted, one response to an unsuccessful direct transfer of technology was to emphasize the importance of local factor endowments and factor prices. A second set of issues concerns distribution and equity.

The move away from direct transfer toward development and transfer of technology by the IARCs involved a series of *planned* allocations of public expenditure, which, in turn, entailed decisions about the type of technology to be developed and the opportunities to acquire it (i.e., about the distribution of benefits). Such decisions undoubtedly increased land productivity; they also, initially, increased spatial or household inequality within the rural economy. This was recognized from the outset in countries such as India (Hopper 1978; Rudra 1987). This awareness and concern for the potential tension

between agricultural growth and equity is epitomized in debates on the consequences of the Green Revolution. It has dominated all subsequent thinking involving science and Third World agricultural development.

Despite the wide range of social science disciplines drawn to analysis of the Green Revolution, there was a broad similarity in the conceptualization of technical change and equity by most analysts within the first generation of Green Revolution studies. The Green Revolution was about the rapid movement from resource-based to science-based agriculture (Hayami and Ruttan 1971). Pearse (1980) characterizes the Green Revolution as "an international campaign aimed at increasing the productivity of land by means of the introduction of a science-based technology in the production of foodgrains."

SSAAR related to the Green Revolution sought to develop conceptual frameworks embracing exogenously generated technical change and processes of transfer to, and impact on, agricultural practice, the rural economy, and society in developing countries. This focus has many restricting consequences. The dichotomized notion of traditional or local versus new, modern, or HYV encourages a research agenda in terms of adopters and nonadopters of specific technology components and further elaboration of the diffusion models characteristic of modernization approaches. To illustrate these arguments, a brief discussion follows of perhaps the two largest research projects in the early 1970s looking at the implications of the new cereal technology: the UNRISD Global Two and the IRRI coordinated project on changes in rice farming in selected areas of Asia.

The IRRI project concerned adoption, constraints to adoption (physical or socioeconomic), and the consequences in terms of productivity. Some constituent case studies explored questions of employment and the partitioning of income streams within farming communities. The project relied largely on cross-sectional farm survey data. Issues such as employment could be looked at through cross-sectional comparisons of the labour requirements of modern and local varieties; however, the full ramifications in terms of socioeconomic change are difficult to quantify where, for example, the landless are not directly considered.

Cross-sectional methods of data collection and analysis involved comparative static analysis of farms "with" and "without" adoption. This approach is inappropriate for calibrating, in any sensitive way, the longer term changes that provide the context of the snapshot of innovation. It needs to be complemented by macrolevel analysis assessing the impact on prices and incomes of government interventions, whether direct (as through the allocation of import quotas) or through taxation and subsidies. Analysis at the community level is needed to assess impacts on such common property resources as stored water and pasture. Shifts in income distribution within or among households and villages need to be addressed by appropriate microanalysis. Subsequent to the initial IRRI research program, some of these issues were addressed by research on the concept of constraints to

the adoption of modern varieties and higher productivity in agronomic and related social science research (IRRI 1979) and the economic consequences of new rice technology (IRRI 1978a). Work on understanding the complex anatomy of village communities was started (Hayami 1978), but received only limited resources.

The thrust of this research effort is toward fine tuning, i.e., knowing more about the environment, the socioeconomic system, and delivery institutions that can provide feedback to agricultural research policy or policy on agricultural production support systems. The wider consequence of this and similar programs has been the development of on-farm agroeconomic research concepts and programs as an integral part of the work of scientific institutions. This has helped to generate, particularly in Africa and Latin America, a whole new subdiscipline of farming systems research. The articulation of this more complex model of feedbacks into formal research is indicated by terms such as "farmer-back-to-farmer" research (Rhoades and Booth 1982) and "interactive research" (Barker 1981).

The UNRISD project had an overlapping set of concerns (Pearse 1980, pp. 1–2) and cross-sectional surveys were again used. However, the analysis was broadened to embrace commercial transactions within the community and a complex of associated access issues (Griffin 1974). A further broadening of perspectives into a concept of livelihoods, rather than a focus on a partitioning of income streams from technical change, makes the community and all households (and members of those households differentiated by sex and age) the object of study. However, this broad approach, in relation to a narrow, simplified notion of technical change, makes it more difficult for the analyst to provide specific data that can feed back into agricultural science. Instead, the analyst provides a more generalized sense of the socioeconomic consequences of technical change, indicating the outcomes that broader technical options imply (Dasgupta 1977). A particular focus is on social institutions — the structures that may contribute to the marginalization of some communities and classes and growing spatial and interpersonal inequalities (Pearse 1980).

The literature on distribution and equity has drawn attention to the highly inegalitarian and potentially economically irrational (in the factor endowments sense) consequences that observed patterns of inequitable distribution of assets can have on technical change. Insofar as there is a demand for technology from within agriculture, this demand often reflects the distribution of productive assets rather than factor prices.

The thrust of the "distributionist" concern is now widely accepted. For example, induced innovation theorists initially focused on the historical significance of factor proportions in long-run patterns of technical change. They now acknowledge the significance of asset distribution in potentially distorting price structures determined by factor endowments (e.g., Hayami 1982). This allows ex ante for the possibility of perverse patterns of technical change. Such change can

only be remedied by incorporating market surrogates that reflect factor shadow prices into bureaucratic decision processes or asset redistribution. These are the policy prescriptions of the distributionist literature (Griffin 1974; Pearse 1980). In recent years, the possibility of transferring technology between economies with very different agricultures and factor price ratios has been enhanced. This increases the risk of inappropriate technology selection within a developing country, unless a policy of using shadow pricing can be made to work.

An important aspect of the distributionist concern has been to shift SSAAR attention to the already severe and potentially rapidly growing pressure on the livelihoods of the landless and marginal cultivating households. Such concerns are reflected in Barraclough's introduction (p. *vii*) to Pearse's (1980) retrospective on UNRISD II:

> The food systems that have maintained humankind throughout most of its history are disintegrating before other forms of economic activity are able to offer alternative means of livelihood to the displaced peasantry.

In conclusion, it is important to note that, by the end of the 1970s, a consensus was emerging on the planned development of agricultural technology for small-scale, resource-poor farmers (e.g., Lipton 1978; Harwood 1979; Collinson 1981; Norman et al. 1982). Many of the equity criticisms of the Green Revolution have subsequently been taken up by farming systems research analysts. They are now promoting technology development for crops produced and consumed in rural areas, with a focus on sustained livelihoods for small farmer client groups.

However, the problem remains that, in many rural areas, landless labourers make up a significant proportion of the rural poor, and certain types of small-farm technology can, in fact, reduce employment opportunities for labourers. This is especially true of poor, rural women (Harriss 1979; Ahmed 1985; Whitehead 1985; Jiggins 1986). The negative employment consequences of certain types of change in mechanical technology in agriculture have been well documented (e.g., McInerney and Donaldson 1975; Biggs et al. 1978; Greeley 1986; Duff 1987; Rudra 1987). It appears, however, that despite these past outcomes there is still a dominant modernization thrust behind mechanization policies, which reflect neither a response to factor prices (or their surrogates) (Binswanger 1978a) nor a concern for agricultural and rural development strategies that promote growth with employment (Stewart 1987).

Another unresolved but related problem concerns the composition of demand for agricultural commodities. Pinstrup-Andersen et al. (1976) bring this point out very forcefully. They use a planner's perspective to establish research priorities on agricultural commodities; they assume that the primary objective of national development policy is to improve the nutritional status of the poor people of Colombia. This study is important because it illustrates the inadequacies of prioritizing agricultural research on the basis only of factor endowments, factor prices, and distributional and equity issues within the agricultural

sector. For national policy, the perspectives must often be broader, accounting for the observed behaviour of research institutes and government.

## *Interrelations between Countries*

Another set of responses to the theory and practice of modernizing Third World agriculture has been that of the writers concerned with dependency relationships in the world economy. In particular, they have been concerned with modernization strategies that promote agribusiness and the integration of agrarian economies within the world capitalist system (Agribusiness Council 1975). This group of writers has been preoccupied with analyzing issues such as

- the role of multinational corporations (MNCs) in the Third World (Burbach and Flynn 1980; Dinham and Hines 1982),
- aid as a vehicle for promoting the interests of international capital (Feder 1977; Burch 1980),
- food aid as a political weapon (Cleaver 1972), and
- the promotion of Third World food production as a means to counter or forestall rural social unrest in developing countries.

Certain writers on this theme have looked at the growing role of MNCs in vegetable and flower production in Third World countries (Burbach and Flynn 1980; Frank 1981; Dinham and Hines 1982). Different out-grower schemes, producer contracts, etc., are analyzed in a centre/periphery economic framework, with the MNC being seen as the centre of a world capitalist system. Thus, the extraction of an economic surplus by the MNC is viewed in the context of changes in real wage rate (by sex) in Third World countries. For example, Feder (1979) analyzed the way in which United States capital dominates and controls the vertically integrated Mexican strawberry industry, which exports to the United States. Young plants from the United States are sent to Mexico for propagation and direct distribution to producers, with little opportunity for adaptation to Mexican conditions. So, although strawberries are an export crop, Mexico does not have its own R & D capability that might give it some control over the development of production practices and markets. Who controls, has access to, and is responsible for R & D capability are principal concerns of the literature in this area.

Recently, property rights in the development of genetic resources has become an increasingly important theme in discussions about the generation and spread of agricultural technology. Mooney (1979, 1983, 1985), for example, emphasizes the implications of the actions of MNCs that have complementary interests in the commercial use of seeds, pesticides and fertilizers in the Third World. These companies have large investments in agricultural technology R & D and are primarily interested in commercial strategies that are profit motivated. Among

other things, this behaviour is identified as contributing to a worldwide reduction in the pool of genetic material (genetic erosion). Although Mooney's earlier analysis is technically incorrect in places, it has been important in bringing these issues into the agenda of SSAAR and in highlighting the political dimension inherent in them. Focusing on this political dimension, Juma (1988) recommends that developing-country farmers be granted legal rights to traditional cultivars in recognition of their effort in selecting and maintaining them.

As research into new agricultural biotechnologies has gained ground, SSAAR interest has developed in issues of control over genetic resources, patenting, and genetic erosion (Stallman and Schmid 1987; Juma 1988). Interest has also developed in the shifting balance between food production based in the field and that based in the factory, and in the economics of cross-sectoral linkages in genetic engineering technologies (Elkington 1985; Hacking 1986; Farrington 1989). Although the impact of biotechnology on agricultural production and world trade is likely to be felt only in the next century, it is already clear that the North's lead in biotechnology will circumscribe options for agricultural technology development in developing countries both directly (through the North's ability to generate new technology and regulate access to it) and indirectly (through displacement of certain imports from developing countries, and, possibly through a lowering of food prices on world markets).

The commercial sector has strong interests in biotechnology R & D. This means that much of its potential to improve plant and animal production will be market-driven, benefiting those products grown on large areas under homogeneous conditions. Biotechnology certainly has the potential to tailor crop improvements to the heterogeneous conditions faced by small farmers; however, the realization of this potential will depend largely on the performance of public-sector institutions at national and international levels. This poses quite new and different problems for international and national research policy. The major issues it raises for the future SSAAR agenda are discussed in Chapter 4.

Other examples of analytical work in this area relate to agro-mechanical technologies. Burch (1980), for instance, examines the reasons for the transfer of tractors to Sri Lanka. In this case study, the role of the British Aid Programme and the promotion of the interests of British tractor manufacturers are emphasized. Specifically, programs of this kind appear valid as part of a modernizing strategy. However, a more thorough analysis of local farming conditions would have revealed that tractors were inappropriate for the declared development objective of Sri Lanka and the farming systems for which they were destined. The study illustrates how the interests of international capital influence the behaviour of aid agencies.

SSAAR literature on the penetration by MNCs into developing-country markets also concentrates on seeds, machinery, and agrochemicals (Jenkins and West 1985). There is a growing coincidence

of interests between writers in this area and those examining the role of MNCs in other areas, such as pharmaceuticals (Melrose 1982).

In summary, those preoccupied with the role of international capital occupy much of the SSAAR platform on international relations. Yet, their conclusions lack balance; comparing the evolution of technology in mixed economies with that in socialist economies would have provided this balance. Some of the problems caused by international capital in mixed economies also occur in socialist countries. For instance, genetic erosion in cereal crops appears to be spreading as rapidly in China as in the rest of East and Southeast Asia (NAS 1972, 1975; Stavis 1978). The promotion of a few dominant varieties, which led to genetic vulnerability, caused a major reduction in both tobacco and sugar production in Cuba in the late 1970s. In addition, modernization strategies involving the use of tractors, improved cereals, and agrochemicals have had very mixed outcomes in socialist economies (e.g., Tanzania — Kahama et al. 1986). Such examples suggest that SSAAR's understanding of technological change is incomplete in this area, and that the activities of MNCs do not provide a full explanation of events. Yet, the policy preoccupations of writers are generally sweeping in nature and emphasize the need for radical change and (until recently) socialist transformation and commitment as the preconditions for better policy practice.

This is the paradox of the many contributions to SSAAR in this area: from outside the institutions responsible for technology generation and transfer, research has unearthed powerful data on specific policy issues. Research findings could stimulate more desirable policies, but only if mechanisms can be found to bring them to bear on the policy-making process. There is, above all, a worldwide problem of responsible practice in agricultural science and technology policy — a theme developed in Anderson et al. (1982). Yet, writers undermine their own credibility by offering sweeping policy prescriptions rather than exploring how to stimulate responsible policy practice. Nowhere is the need for a focused, policy-specific approach by social scientists more evident than in biotechnology.

## *Environmental Themes and Ecological Crisis*

The SSAAR analysis of environmental and ecological issues is a critical response to the simple modernization perception of agricultural development as a race between increasing food production and population growth in the developing world. Writers on environmental and ecological issues focus on the decline of soil fertility, land degradation, soil erosion and abandonment, chemical pollution, desertification, salination, deforestation, overgrazing, siltation of irrigation systems and reservoirs, flooding, and the depletion of fishery resources. At the international level, increasing attention is being given to global warming and the greenhouse effect (*Scientific American* 1989). In the North, the economics of natural resources and the environment is

becoming an important theme on political agendas and a number of theories are being developed (Pearse and Turner 1990).

Distinguishing features of the work in this area (*Scientific American* 1989) are the exploration of

- the actual or potential long-term destructive consequences of specific short-term agricultural production activities,
- the interrelationships of economic activities from one geographical area to another,
- problems of ecological balance,
- the use of renewable and nonrenewable resources,
- the interaction of geographically specific physical, demographic, and social relationships, and
- the use of "common property resources" (Jodha 1985, 1987), whether at a local or international level.

In the past, much of the writing on the environment and ecology has fallen into two categories. First, there is technical literature with strong, single-purpose policy recommendations on phenomena such as desertification, soil conservation, and overgrazing (United Nations 1977). Policy analysis has emphasized the need for, and practicalities of, single-focus interventions such as woodlots, dams to stop gully erosion, social forestry, and community action. Second, there is much literature that attempts to integrate environmental issues into a wider political economy analysis (e.g., Bernstein 1979; Franke and Chasin 1980; Blaikie 1983; Blaikie and Brookfield 1987).

In developing a theory for the political economy of soil erosion, Blaikie (1983) highlights the key elements of, first, the interaction between social and physical systems in a specific geographical region (a place-based orientation) and, second, the importance of the specific historical and other contextual settings of the region. In a Marxist analysis of some of the causes of local soil erosion, Bernstein (1979) describes the process of a simple reproduction squeeze: terms of trade deteriorate against peasants, which leads to lower consumption or intensified commodity production. This initiates the cultivation of poorer or more distant lands, resulting in lower returns to labour and a possible deterioration of the resource base.

Many writers on environmental problems see capitalism as a major cause of the environmental crisis. Writers with a Marxist orientation, however, are either strongly divided or have not addressed the issue in a policy or contemporary setting.

Until the late 1970s, analysts amassed data that could imply a specific and powerful policy agenda; however, they did not construct specific and feasible agendas for today's policymakers. In this respect, there are clear parallels with the paradoxical character of the world economy literature.

However, the 1980s have seen major changes in the writings and practices of natural scientists and social scientists concerned with environmental issues. Within the technical community, Sanders (1988) identifies two major shifts:

- Scientists have placed much greater emphasis on understanding the underlying social and technical causes of land degradation.
- Soil conservationists have developed techniques and practices that not only halt land degradation but also provide farmers with direct short- and long-term benefits.

In a discussion of measurement and problem diagnosis in soil science, Stocking (1987) clearly illustrates the limitation of narrow disciplinary approaches by soil scientists.

In the field of policy and planning there has also been a significant shift. There is now a growing literature that is far more definite and concrete as regards applied policy analysis and change (e.g. Shah 1982; Bruntland et al. 1987; Davis and Schirmer 1987; Repetto and Gillis 1988; Abel and Blaikie 1989).

At the levels of program formulation and project analysis, methods have been developed to include the explicit analysis of soil degradation and other externalities in agroforestry projects (Prinsley 1990). Also, the concerns of geographers are increasingly being noticed by international agricultural research centres (Bebbington and Carney 1990).

These shifts in attitude and the development of practical applied frameworks for integrating social and technical analysis of land degradation (Blaikie 1989) are significant for agricultural research analysis. They reflect the opening of important new agendas and provide empirical illustrations of research that must become more central to agricultural science.

## *Research and Extension Institutions*

Compared with many of the other themes discussed in this chapter, the literature on agricultural research and extension institutions is relatively recent (for collections of articles, literature reviews, etc., see Fishel 1971; Hayami and Ruttan 1971; Rogers 1976, 1983; Arndt et al. 1977; Binswanger and Ruttan 1978; Schuh and Tollini 1979; Scobie 1979; Stavis 1979; Brokensha et al. 1980; Gilbert et al. 1980; Busch 1981; Norton and Davis 1981; Whyte 1981; Biggs 1982; Pinstrup-Andersen 1982; Ruttan 1982; Shaner et al. 1982; Biggs and Grosvenor-Alsop 1984). It includes material on the historical development of research institutes, nationally and internationally. There is also a growing literature on principles, techniques, and methods for organizing and managing agricultural research (e.g., Arnon 1975; Byerlee and Collinson 1980; Daniels and Nestel 1981; ISNAR and IADS 1982). Here, as a prerequisite to the application of management techniques, we focus on the subset of literature that describes

institutions and seeks to draw up analytical frameworks for understanding their behaviour.[3]

In the literature on research and extension institutions, there are several models of institutional change. Each model offers its own explanations of differences in the structure, management, and behaviour of research and extension institutions over time and space.

## *Stages of growth models*

An approach to understanding why a research system has certain characteristics is to see it as a specific stage in the historical evolution of systems in general. For example, Evenson (1978, p. 240) suggests four stages in the evolution of agricultural research:

- pioneering stage of institution development,
- simple adaptive system stage,
- advanced adaptive system stage, and
- technology-potential capacity stage.

In the same tradition, Ruttan (1988, p. 99) gives three stages that are characterized by different activities:

- innovative activities of individual farmers and inventors,
- organization of agricultural experiment stations staffed by research workers, and
- evolution of integrated national agricultural research systems.

Esman (1978) identifies four models for the development of R & D in and for developing countries over the last 30 years:

- extension model (emphasis on transferring established knowledge to farmers),

[3] We are not reviewing the literature on rates of return to investments in agricultural research (e.g., Evenson 1975; Schuh and Tollini 1979; Scobie 1979; Ruttan 1982). One of the reasons is that this literature does not seek to explain *why* good or bad investment decisions were made in the past. Some of the original work in this area was done by Griliches (1958) on maize in the USA; since then, there have been many studies that have looked at different commodities in developing countries. Generally, high rates of return have been estimated (e.g., ≥30%), although a few studies have taken examples where there have been low and negative rates of return (Wennergren and Whitaker 1977). In the literature on this subject, there are fierce debates about whether, and how, costs and benefits from technological change can be meaningfully estimated and allocated between different categories. For example, see Wise (1978), who questions the logic and internal consistency of the Griliches exercises, and the work of Lindner and Jarret (1978) and Norton et al. (1981).

- land grant college (LGC) model (transfer of the LGC institutional structure to developing countries),
- big science model (setting up of the international agricultural research system to generate technology for transfer to farmers and national systems), and
- interactive model (methods for providing appropriate technology to farmers by-passed by the Green Revolution and strengthening the linkages between farmers, researchers, and extension workers).

Such stage models are, at least as with Esman (1978), an attempt at a stylized history, intended to draw out significant developments. However, for the most part, these models are in keeping with an approach that emphasizes the transfer of technology and institutions from rich countries to poor countries, or, as some writers see it, transfers from "the centre" to "the periphery." Transfers can help countries by-pass or move through stages more quickly. These stage models carry a normative loading by implying that there is an inevitable or desirable evolutionary profile through which systems pass. For policymakers concerned with country- or region-specific problems and specific technologies in a changing political setting, these normative stage models give relatively little help.

### *Induced institutional change model*

Early thinking on induced technological change (Hayami and Ruttan 1971) has been extended to cover issues of induced institutional change. This model defines four interrelated groups of factors: resource endowments, cultural endowments, technical change, and institutional change (Ahmed and Ruttan 1988). National factor proportions and relative factor prices (or scarcity) are at the heart of the model. According to this approach, technical and institutional change are highly interwoven and must be analyzed within the context of interdependence.

The proponents of this model suggest that testable hypotheses can be generated regarding, first, alternative paths of institutional change over time for a particular society and, second, divergent patterns of institutional change among countries at a particular time. Several writers have sought to test and elaborate this model in case studies of research mobilization in mixed and socialist economies (e.g., Ahmed and Ruttan 1988; Dorling 1988; Luu 1988) and for international agricultural research (Ruttan and Binswanger 1978).

One of the problems is that the system is indeterminate (Ruttan 1988). The direction of causation is specific to any given situation. This means that the model is difficult to test, especially in the short run, because it does not specify under what conditions one would expect the causation to be in one direction or the other. For example, what does the model explain in a mixed economy like Kenya where horticultural growers appear to exert little direct pressure on the horticultural

research system? It is left mostly to government officials and organizations to decide what needs doing; yet, the system has responded well in the last two decades to supplying recommendations for technical innovation (Dorling 1988).

In this case, have the right research institutional structures already been induced or are they still to change and, if so, should fast or slow change be expected? Should Kenya give higher priority to horticultural research? Horticulture is important to the livelihoods of the majority of farmers (who have small farms); yet, public expenditure on research and development in horticulture is less than proportional to the industry's contribution to the total crop value in agriculture. Does this mean that, despite its apparent success, the research service has not responded well and institutional change will be induced shortly to increase horticulture's share? If this is so, what specific types of political activities would we expect to occur in Kenya?

In the case of Vietnam, one stage of innovation was dominated by a transformation of production relations so that the government could "buy time" for agricultural sciences to develop and produce some useful and practical discoveries (Luu 1988). This was in response to the constraints that had emerged in previous modernization campaigns, including a farming system that could not accommodate multiple cropping without new technology, a weak and atomized peasantry, and the inability of the socialist government to provide investment to stimulate agricultural production.

In this context, we must find the political structures and cultural endowments that differentiate, say, Kenya from Vietnam, lead to "mistakes" being made, or permit new directions of technical and institutional change to be established. Even as "technologists," Ruttan and Binswanger (1978) express some apprehension about the capacity of technical change to induce institutional innovation. Few analysts would agree that technology can be *isolated* as the leading factor of change. This is particularly true of countries that have experienced the Green Revolution.

It would seem that, in certain applications of the model, cultural endowments may be used to represent the degree of equity in the society. In this reformulation we would have a general (as opposed to partial) economic model that accounts for the distribution of income and its effects on the composition of aggregate demand and commodity prices. This type of change to the induced innovation model, however, brings it closer to the models of social scientists who have, for years, been looking at broader, social, economic, bureaucratic, and political determinants to understand the existence and changing character of research and extension systems (Griffin 1974; Clark 1980a; Brass 1982; Rudra 1987).

There would be near universal acceptance of a proposition that institutional behaviour is sensitive to and reflects its socioeconomic, political, and cultural context. In this sense, there is always induced institutional innovation. The work of de Janvry (1977) is used by Ruttan

and others and is helpful in making more explicit the fact that socioeconomic and politicobureaucratic structures are important. However, for policy-relevant research, such structures require separate, detailed analysis. They must not be lumped into a regression equation as one or more dummy variables. Apart from the methodological problems of assigning values, such a procedure reduces these variables to the status of "black boxes" and diverts attention from the need for a detailed understanding of their role.

In summary, although an important contribution to the literature, the induced innovation theory focuses on resource endowments and on "getting factor prices right." In doing so, it shifts attention away from the *way* in which political power or wealth influence the allocation of research resources to and within particular commodity/technology programs. At the same time, it hides the fact that differences between prices reflecting *short-run* market values, and those reflecting *longer term* societal goals are not easily reconciled. For instance, only *after* the 1972–1974 rise in oil prices was research reoriented toward greater energy efficiency, although it had long been known that fossil fuel reserves were limited. Similar issues arise in cases of environmental degradation — resources are extremely difficult to "price" at their real value to society. In short, because today's technology is potentially so powerful, legislation or other institutional change induced in response to short-term prices may be ineffective or too late to prevent irreversible long-term changes that have very high social costs.

## *Decentralization models*

Rogers (1983) proposed a model of R & D that contrasts with the transfer of technology and induced institutions approaches. Although developed outside agriculture, this "decentralized" model is relevant because it seeks to explain observed behaviour and processes that do not fit in the conventional centre–periphery thinking. Rogers shows how a decentralized model helps in understanding innovation and diffusion in two widely different contexts: barefoot doctors and self-reliance movements in China and energy conservation technologies in the United States.

In the decentralized model, roles are accorded to the centre *and* the periphery as sources of innovation and as actors in the process of dissemination. Despite the fact that a hierarchical view of the transfer of technology and institutions pervades thinking and *practice* in many agricultural research and extension systems, there are many instances in which, in reality, the generation and diffusion of innovations is nonhierarchical. These cases tend to be undervalued because few resources are allocated to feedback and to the collection of changing local knowledge. Furthermore, the contrast between centralized and decentralized R & D models, and the fact that each can be found in practice, suggest that there is no universal model that offers a prescription for every circumstance.

It would be useful to apply this decentralized model to an analysis of the actual behaviour of some major national and international research and diffusion systems. For policy purposes, the model is helpful because it highlights different and complementary sources of innovations and the respective roles that different institutions might play. This has important implications for the allocation of scarce research resources. Some of Rogers's early thinking is developed further in the conceptual framework for the analysis of SSAAR in Chapter 3.

## *Political science and sociology models*

The range of political science and sociology models is very broad. It includes the work of social scientists on the internal workings of research institutions and the different external political, economic, foreign donor, and other determinants that influence the behaviour of research and extension institutions. In each case, studies can be categorized according to the extent of external influence.

Brass (1982), for example, analyzes the LGC model to establish the G B Pant University of Agriculture and Technology in India. Brass's investigations of the motivating forces behind the University and of why only parts of the institutional model were transferred reveals that an eventual crisis at the University was inevitable. Other social scientists had long foreseen the problems with creating research capability by transferring a specific institutional model and had suggested alternative paths of institutional change (Hart 1961; Hunter 1969). Other studies on the outcomes of the LGC model have been conducted by Fitzgerald (1981). It is interesting to note that in the United States there is a growing critical literature on the role of the LGCs in meeting policy objectives (Hightower 1976; Hadwiger and Browne 1987).

In a case not involving "transfer" of institutional forms, Stavis (1978) reviews development of the agricultural research and extension system in China. He explicitly analyzes the political social structures that resulted in the close control over research capabilities by potential clients of research.

Another type of analysis by sociologists and political scientists examines the professional behaviour of scientists within institutions (e.g., Beveridge 1957; Binswanger 1978b; Ladd 1979, 1987; Busch et al. 1980; Busch and Sachs 1981; Shumway 1981; Gomory 1983; Latour 1987). For example, rice breeders in Asia rank production problems in their own countries in one order, but carry out research on items ranked in a different order (Hargrove 1977). Studies conducted elsewhere (e.g., USA — Busch et al. 1980) identify *internal*, institutional factors that influence the behaviour of scientists, including

- interaction with peer groups over the content of training and education programs,
- the development of new theoretical orientations and methods,

- the historical development of the various agricultural disciplines, and

- the processes of senior staff recruitment and promotion.

Gupta (1987a) shows that researchers in India are highly aware of the problems of conducting research on rainfed crops and, where possible, have opted for irrigated areas.

A growing area of independent research in the last 10 years has looked at political and bureaucratic factors that have determined the behaviour of international agricultural research institutes and national governments. In Korea, Burmeister (1987, 1988) shows how high-level, bureaucratic decisions directed what technology was promoted, irrespective of farmers' requirements. Anderson et al. (1990) critically review the role of the International Rice Research Institute in promoting rice research in Asia. This study, like the work of Jennings (1988) on wheat research in Mexico and Koppel and Oasa (1987), which concentrates on the myth of technology neutrality, shows how the direction and scope of international and national agricultural research is influenced by political considerations.

A relatively new area of analysis concerns the respective roles of private- and public-sector research.[4] Trigo and Pineiro (1981) show how private-sector research that specializes in the problems of commercial farmers of the modern sector is attracting national scientists away from the public sector in Latin America. This has two consequences: the public sector tends to be left with a cadre of less experienced scientists and the focus of research is shifted toward higher income groups. Pray (1983), reviewing the Asian experience, anticipates that private-sector research will expand substantially from its small base. Government incentives to local and multinational companies are likely to encourage greater private sector involvement.

The political science and public administration approaches to understanding research institutions go beyond identifying the specific interest groups, classes, funders, etc., who influence the context in which technology is developed. In such studies, the internal dynamics of bureaucratic institutions and the way in which they interact with other institutions and individuals are *explicitly* taken into account. Also, policies to improve the institutional performance of public-sector research systems must grapple with the *specifics* of a system, particularly with resource allocations and the short-run efficiency of system components. Therefore, political science and sociology models have a major potential for helping policymakers in agricultural research.

[4] This type of analysis is concerned with formal (institutionalized), private- and public-sector research and does not relate to the informal research by farmers and rural artisans as described and discussed by Bell (1979), Brammer (1980), Biggs and Clay (1981), and some of the articles in Brokensha et al. (1980).

## *Organization and management models*

There is a substantial and growing literature focusing on how research and extension systems should be organized. Generally, it covers principles, methods, and techniques for collecting and analyzing management data. Procedures on how different components of a research and extension system should be organized and managed are also outlined.[5] The literature can be split into four major areas: priority setting in agricultural research, monitoring and evaluation, management methods for agricultural research, and on-farm and farming-systems research.

### *Priority setting in agricultural research*

In the early years of institutionalized agricultural research in the North, those responsible for resource allocation identified research priorities largely based on direct interaction with farmers. In Britain, for instance, the economics of concentrating specialized skills and facilities in one place became evident. Only then was the experimentation previously conducted by farmers assigned to the world's first publicly funded agricultural research station at Rothamsted. Similarly, in the early development of LGCs, extension agents representing farmers' interests strongly influenced the research agenda (Stavis 1979; Busch and Sachs 1981). With increasing complexity both in agricultural production systems and in research, decision-makers have begun to use more formal methods of resource allocation (Contant and Bottomley 1988):

- *Checklists:* Lists of major government objectives are used to assess whether funds should be allocated to a research area (Biggs 1978; Pray 1979).
- *Pay-off matrices:* Matrices of gainers and losers are drawn up to select research priorities and assess actors (including researchers) who will gain and lose from a change in policy (Biggs 1978; Biggs and Griffith 1987; Stewart 1987).
- *Research resource inventories:* The total current allocation of financial and human resources are disaggregated by a number of criteria (e.g., commodity, region and central station, local or foreign source of funds). This provides a systematic framework for reviewing and planning research (Daniels and Nestel 1981).
- *Parity ratios:* Research spent on a crop or technology is related to its contribution to total agricultural value added (Dorling 1988). These ratios, together with the aggregate congruence index (Boyce and Evenson 1975) can be used to explore the rationale and justification for inequitable ratios.

[5] For example, the farming systems research and resource allocation literature coming from the IARCs.

- *Benefit–cost analysis (ex-ante):* The returns to alternative research expenditure patterns are compared. This was well illustrated by Barker (1981) when reviewing the costs and returns to investments in rainfed vis à vis irrigated rice research.

- *Scoring models:* The subjective judgments of different scientists on the importance of a problem and the likelihood of finding a solution within a specific period of time are accounted for. The delphic technique is an example of a scoring model (Chapparro et al. 1981).

- *Complex models:* These models generally take national resources and national development goals, and work back to an optimal plan for research resource allocation (Pinstrup-Andersen et al. 1976; Davis et al. 1987). Norton and Pardey (1987), after working with several national programs, conclude that the most important value of the complex models is to provide a framework for working with research managers. They stress that the exercise has limited value if local research managers are not totally involved in the activities.

With increasing specialization of skills in research, a widely held view is emerging that resource allocations are too strongly determined by scientists on the basis of their own interests and career priorities. Isolationism in the laboratory or on research stations has reduced farmers' influence on the research agenda (Chambers and Ghildyal 1985; Chambers et al. 1989). In response, strategies have been developed to increase farmers' "demand–pull" on the research agenda (Röling 1988; Farrington 1989). Many of these are discussed in other contexts elsewhere in this book. They include

- the shift toward client-oriented, on-farm research programs (Harwood 1979; Collinson 1982),

- the search for models of participatory research (Rhoades and Booth 1982; Chambers et al. 1989),

- the search for public-sector institutional forms that bring farmers' requirements more strongly onto the research agenda (Kean 1986; Merrill-Sands et al. 1989; Farrington and Mathema 1990), and

- the search for more effective modes of collaboration between agencies within the public sector and those outside it, such as NGOs and farmers' organizations (Farrington 1988; Farrington and Biggs 1990).

### *Monitoring and evaluation*

Recently, increased attention has been given to monitoring and evaluation, especially by ISNAR (e.g., McLean 1988a,b,c). It has also been the topic of a major international workshop of research managers from developing countries (Daniels 1987). The problems of monitoring and evaluating research include those inherent in selecting a limited number of useful performance indicators. Another difficulty is that, where funds are limited, emphasis may be given to monitoring for

evaluation purposes rather than to monitoring for purposes of learning and responsive management.

### *Management methods for agricultural research*

In recent years, the concern for the management of agricultural research has grown. There has also been a shift from prescribing "optimal" management mechanisms to a more cautious approach. In this latter approach, existing agricultural research systems are reviewed and, when specific management techniques (or institutions) are found to perform a specific function well, the full institutional and policy context of the situation is analyzed (Merrill-Sands and McAllister 1988). This shift in orientation means that management mechanisms are not recommended unless there is detailed institutional and political analysis of the context for which the recommendation is made. Similar caution is evident in other management studies, including those on the management of linkages between research and extension (Kaimowitz 1990).

An area requiring greater attention in the management literature is that of administrative policy. At one level, it is often suggested that good researchers in public-sector organizations "should be" rewarded and promoted for their efforts (Bennell and Thorpe 1987). In practice, however, the introduction of even minor performance-related incentives or improved allowances for those working in remote areas is bound to require major negotiations, as research institutes are commonly linked to employment conditions prevailing throughout the public sector. The question of whether those joining agricultural research services are motivated more by a desire for job security than for performance-linked benefits has been a major theme in the general public administration literature. However, it has been given little consideration to date in SSAAR (Harvey et al. 1979; Clark 1980b; Leonard 1987).

### *On-farm and farming systems research*

There is a very large body of literature on approaches, methods, and techniques that may be used in on-farm and farming systems research. The bibliography contains several of the manuals issued by international agencies (e.g., de Datta et al. 1978; Byerlee et al. 1980; Tripp and Woolley 1989). There are also manuals prepared by national research institutions in many countries (e.g., Nepal and Bangladesh). One of the major findings of a recent review of on-farm research for small farmers in nine countries was that at the field level the programs had often not worked closely with small-scale, resource-poor farmers (Ewell 1988; Biggs 1989). Implementing the prescriptions of on-farm research manuals has been uniformly difficult. Increasingly, on-farm researchers are now having to address the "institution and policy context" issues that were frequently neglected in the earlier literature on this type of research.

The emphasis on logical and cost-effective approaches is a major strength of the literature in this area; however, there are limitations.

For instance, prescriptions for future action presuppose that there is a model (or understanding) that adequately explains past events and allows identification of viable options for policy analysis and action in the future. Preoccupation with this type of management literature can divert attention from, first, understanding scientific systems and, second, an awareness that political and institutional factors determine whether techniques are used in a ritualistic or a real sense in any given situation.

## *Concluding Remarks*

The historical review of theories of agricultural technology generation and diffusion in this Chapter has sought to identify sets of themes and preoccupations that have resulted in different theories and policy actions, and to trace their evolution. We have concentrated on events of the last 30 years because the political and socioeconomic conditions of these years make them relatively more important to future policy action than earlier events.

Our review indicates that the generation and dissemination of technologies for areas that are not irrigated or reliably rainfed has proven much more difficult than was anticipated in the 1960s and 1970s. Conjecture over a "Green Revolution for Africa," for instance, which was then common, has given way to twin realizations.

First, research and dissemination will, in many countries, achieve little unless accompanied by changes in the broader economy. SSAAR must identify necessary reforms relevant to research and extension more systematically than it has done. Also, the policy recommendations of SSAAR must be consistent with the modest scope for change that will, at best, be available in the wider economy.

Second, agriculture outside the irrigated and reliably rainfed areas has potential for substantial productivity increases; however, new technology will have to be tailored to the diverse and complex agroecological and socioeconomic conditions of these regions. For example, SSAAR could make a major contribution to balancing the allocation of research resources to these areas, assisting in the design of appropriate institutional forms for research and dissemination, and developing appropriate research methods.

Within this broad context, particular trends in SSAAR point toward an analytical framework, constructed in the next Chapter, to identify future priorities for SSAAR.

### *1. Institutions are an important criterion.*

There are two reasons why institutions are an important criterion. First, a simplistic, hierarchical conceptualization of agricultural research and dissemination is a highly incomplete account of reality.

This view often corresponds with "basic" research at the international level, followed by "adaptive" research at the national level and dissemination at the local level. It is a conceptualization couched in "technology-transfer" thinking.

As research priorities shift toward complex and diverse rainfed areas, the relevance of this conceptualization becomes even more tenuous. Various challenges (reviewed by Biggs 1989a) have elicited neither a reasoned response nor a change in practice on the part of both natural and social scientists committed to "technology-transfer" thinking. If alternative approaches are to be found, SSAAR will have to give further attention to the institutional context, within and outside the public sector, in which innovation occurs. The justification for this is reinforced by the particularly poor performance of modernization thinking when applied to the transfer of institutional forms from North to South.

Second, SSAAR has started to review management methods for improving the efficiency and client orientation of research. Studies focus largely on public-sector institutions and their relations with the IARCs; however, they do not place their recommendations within the context of constraints inherent to the public sector at large. Nor do they consider in any depth the gains in efficiency that can be made by exploiting complementarities through collaboration among institutes across public, commercial, and voluntary sectors, and through collaboration with the informal research conducted by farmers.

### *2. Environmental issues are important.*

The limited success of direct technology-transfer approaches has stimulated work by SSAAR analysts on the extent to which innovation will be induced by variations in local factor prices and endowments. The implications of this work (i.e., that governments should "get the prices right") are indisputable. In spite of this, SSAAR has given relatively little attention to divergences between short- and long-term prices and the depressing effect that a focus on short-term prices may have on the volume of research to be allocated to environmental issues.

### *3. Continuous problem diagnosis and feedback are essential.*

The framework will have to explicitly recognize the importance of problem diagnosis and feedback from one level of technology user to another (e.g., from farmers to national research and extension services, and from these to international centres). Existing approaches have consistently failed to stimulate "reverse flows" of this kind; yet, they are a powerful source of information and ideas and are likely to draw the research agenda closer to farmers' requirements (Kaimowitz 1990).

### *4. Resource-poor regions need closer attention.*

Many factors have recently stimulated natural and social scientists to give closer attention to areas with difficult farming conditions. These include

- increased research costs of achieving productivity gains in better endowed areas,
- concern over continuing increases in population pressure in rural areas and limited growth in the absorptive capacity of the urban sector (Birdsall 1985), and
- concern over the environmental effects of what are frequently nonsustainable agricultural practices in ecologically fragile areas.

### *5. Resource-poor rural people must influence research.*

Much of the evidence from the last 30 years shows that low-income farmers do respond to new technology that is appropriate, low cost, low risk, and does not impose major new learning requirements (Chambers et al. 1989). If resource-poor farmers and landless labourers are to benefit from public sector research, they must do more than simply participate in the experiments. They must be able to influence the direction and content of research.

In conclusion, the proposed framework for classifying and prioritizing SSAAR needs to be general in character. However, it should also be adaptable to specific conditions, such as those relevant to small farmers, if it is to play a useful role in this emerging context. In particular, the framework needs to channel attention away from models that view the demand for technology in terms of factor endowments and see "getting the prices right" as a major step toward the efficient allocation of research resources. Although indisputably desirable, such prescriptions are inadequate in remote and difficult areas where markets function poorly and political power is generally inferior to that exercised by large farmers.

## *Chapter 3*

# *Building a Framework to Analyze SSAAR*

In the first chapter, two limitations of existing frameworks for analyzing SSAAR were noted. First, it is difficult to identify areas that require closer SSAAR attention. Second, they do not highlight developments in agricultural research that will require SSAAR.

In this chapter, we construct a framework for classifying and analyzing SSAAR that addresses these difficulties. This framework is, to a large extent, empirically derived: its origins can be traced to many of the arguments presented in Chapter 1 and to the findings of the review conducted in Chapter 2. Literature supporting key elements of the framework is cited during its construction. However, in Appendix 1, a much wider literature is classified under 24 themes relevant to the framework and the reader may find it useful to refer to this throughout the chapter.

The framework is developed in three broad stages. The first stage involves classifying technology and identifying the level at which research into distinct types of technology is normally conducted. In the second stage, a framework of analysis is constructed based on institutions and the interactions among them. In the third, an historical dimension is introduced into the institutional framework.

## *Stage 1: A Technology Dimension*

A classification based on *type of technology* offers many advantages. It allows an assessment of which technologies have received the bulk of SSAAR attention. Gaps in the technology coverage of SSAAR can also easily be identified. If defined widely enough, a technology-based classification can also capture literature beyond that which is directly crop specific, e.g., literature on farming systems interactions, common property resources, and environmental impact.

As with typologies based on time and space, "overlays" of other classification systems can augment the basic technology-based system. A simple spatial overlay incorporating national, local, and household-level categories has been used to identify factors that influence the

development of technology (Biggs 1978). This is further developed here (Table 2). Technologies can be defined narrowly in terms of production categories (fodder, etc.) or in terms of facilitating technologies relevant to several production categories (irrigation, mechanization, etc.). One of the potential shortcomings of this type of classification is evident in Table 2: for the typology to capture issues beyond individual production categories, technology must be defined broadly; however, the more broadly it is defined, the more difficult it becomes to ensure that categories within the typology are mutually exclusive.

A more serious disadvantage of this typology is that it does not easily accommodate institutional conditions, which influence

- the prioritization of technologies for research,
- the degree of success in pursuing such research, and
- the feeding back of previous R & D experience into the planning of new research programs.

A classification by technology type provides research managers with an initial orientation; however, they cannot ignore institutional issues of this kind.

Table 2. Framework for the analysis of agricultural research: relationship between level of research and type of technology.[a]

| Technology | Level of research | | | |
|---|---|---|---|---|
| | International | National | Local | Household |
| Varietal selection | S | S | S | S |
| Animal breeding | W | S | S | S |
| Fodder | W | S | S | S |
| Pest control | S | S | S | S |
| Biotechnology | S | S | N | N |
| Food processing and storage | W | S | S | S |
| Irrigation | W | S | S | S |
| Farming systems research | N | S | S | S |
| Agricultural equipment | S | S | S | S |
| Agricultural mechanization | S | S | N | N |
| Germ plasm collection | S | W | N | N |

[a] S, strong; W, weak; N, none.

## *Stage 2: An Institutional Dimension*

Institutions are the primary criterion around which the framework is constructed. As we have argued, they are centrally important in enhancing perceptions of why and for whom certain types of technology are developed. Important issues *within* institutions (represented by the boxes in Fig. 1) include the behaviour of scientists and research institutions, research prioritization and resource allocations, the structure and management of institutions, identification of the institutions' clients, and mechanisms for promoting responsiveness to clients' needs. Those responsible for setting the future direction of SSAAR, whether independent institutes or individuals, or research managers in the public or voluntary sectors, find that many of their decisions *implicitly* account for institutional issues such as mandates and sources of funding. Figure 1 makes these considerations explicit. Apart from their conceptual importance, therefore, institutions form a strong practical basis for decision-making.

### *Incidence of research*

The frame thickness of each box in Fig. 1 reflects the authors' subjective impression of where the bulk of SSAAR studies on *intra*-institutional issues has fallen. A thick frame represents strong emphasis on SSAAR; a thin frame, moderate emphasis; a broken frame, weak emphasis. For example, the activities of multinational corporations tend to attract SSAAR (see Appendix 1, theme 18); private companies in developing countries have seen less SSAAR (but see the work on agromechanical technology — e.g., IRRI 1986 — and private sector R & D — Ruttan and Pray 1987). There is little literature on the work of NGOs in agricultural technology, whether at the international, national, or local level. However, the recent proliferation of newsletters partially or wholly dedicated to NGO activity has begun to redress this imbalance.

An imbalance is also evident within the public sector. There is an abundance of reviews and planning documents related to international centres, and similar studies on national research services (commonly assessing whether they perform well enough to make use of what the international centres have to offer). Yet, there is a distinct lack of studies that discuss the motivation and behaviour of developing-country scientists (Appendix 1, theme 11), or ways in which the international centres can be made more responsive to the requirements of national centres.

It should be noted, however, that the observed distribution of literature cannot be immediately translated into guidelines for research managers. A thick frame does not, for instance, indicate that the scope for SSAAR has been fully exploited. There are two broad reasons for this. First, intra-institutional issues may be much more complex in certain types of institution, therefore requiring more SSAAR. For

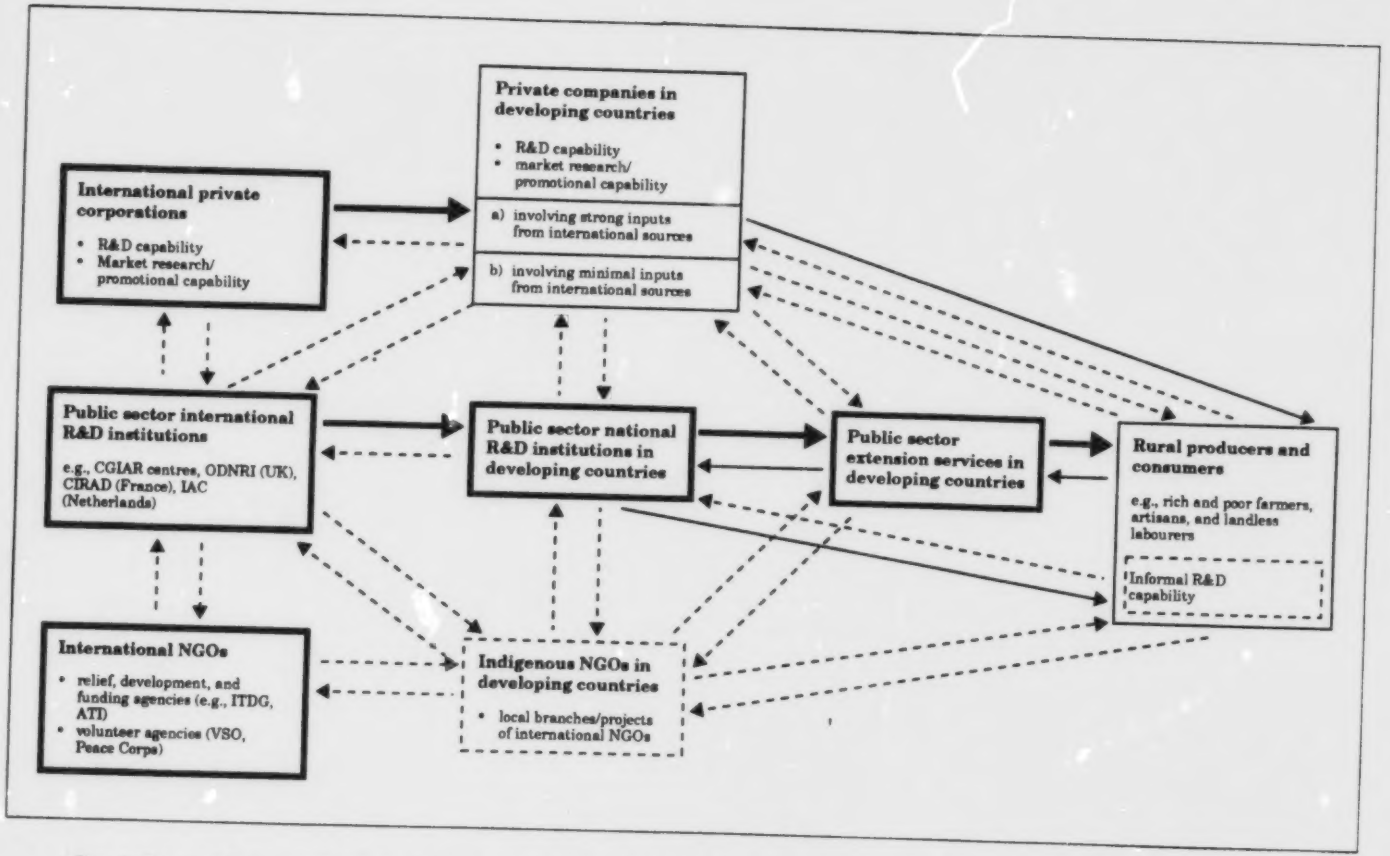

Private companies in developing countries
• R&D capability
• market research/ promotional capability
a) involving strong inputs from international sources
b) involving minimal inputs from international sources
International private corporations
• R&D capability
• Market research/ promotional capability
Public sector international R&D institutions
e.g., CGIAR centres, ODNRI (UK), CIRAD (France), IAC (Netherlands)
Public sector national R&D institutions in developing countries
Public sector extension services in developing countries
Rural producers and consumers
e.g., rich and poor farmers, artisans, and landless labourers
Informal R&D capability
International NGOs
• relief, development, and funding agencies (e.g., ITDG, ATI)
• volunteer agencies (VSO, Peace Corps)
Indigenous NGOs in developing countries
• local branches/projects of international NGOs

*Fig. 1. General framework for classifying and analyzing SSAAR by type of institution and the interactions among institutions.*

example, research agenda in commercial companies are driven primarily by the profit motive; therefore, they are uncontentious compared with agenda in the public sector, which may have to meet a wide range of criteria. Second, certain SSAAR, usually at the empirical level and relating, for instance, to the economic analysis of experiments, is highly specific to time and location. Even though a type of institution may, in global terms, already have been the subject of much SSAAR, more will be needed to address new issues as they emerge in specific contexts.

Similarly, a broken line does not automatically indicate a gap in SSAAR. Particular types of institution may have received little SSAAR attention because they are oriented more toward agriculture in the industrialized countries of the North than in the developing countries of the South (e.g., the commercial sector).

Identifying "high payoff" areas for SSAAR is discussed in a subsequent section. The framework can be used ex-post to help identify what studies have been done, or ex-ante to aid in the selection of SSAAR topics. Here, it is sufficient to note that Fig. 1 is intended as a frame of reference, orienting SSAAR decision-makers by identifying the types of institution potentially relevant to their decisions, as well as the interactions among institutions.

## *Interactions among institutions*

Interactions between institutions are also indicated in Fig. 1. The thickness of the arrows indicates the strength of the interaction; broken lines indicate a weak interaction. In principle, interactions could be identified among all the research and extension boxes. When selecting potential social science research, the research manager should consider all possible linkages (see Chapter 4). In Fig. 1, there are two broad types of interaction: "vertical" and "horizontal."

### *Vertical interactions*

The three rows in Fig. 1 correspond to broad institutional types defined by ownership characteristics and objectives (i.e., private commercial, public-sector, and voluntary agencies). Flows of information and technology among these broad types tend to be weak. Interaction between the private and public sectors have been limited to issues such as trials with equipment, agrochemicals, and seed. However, public-sector agencies have supported equipment manufacture by developing-country firms (e.g., IRRI–Thai collaboration on axial-flow threshers — Mongkoltanatas 1986).

The importance of small-scale, private-sector blacksmiths and artisans working with farmers to develop and modify agromechanical technologies is increasingly being recognized (Basant 1987, 1988). This has prompted the question of how these activities might best be supported by public-sector research institutes. In the future, the

exchange of technology, ideas, and information, as well as SSAAR, in this area is likely to increase.

In the broader context, there is likely to be an increasing need for the private and public sectors if not to work directly together, then at least to search out, acknowledge, and react to each other's chosen spheres of activity. Two areas in which this will be particularly relevant are environmental protection and biotechnology.

There is practically no interaction at all between the private commercial sector and NGOs. What interaction there is occurs through NGO "campaigning" activities, such as those conducted by the Seeds Action Network against proposed strengthening of patents registration on new seed varieties.

### *Horizontal interactions*

A second dimension in Fig. 1 (from left to right along rows) indicates interactions among institutions within the same broad category (public, commercial, voluntary) and between them and various rural clients. Reading from left to right, institutions are classified at international, national, and subnational levels. Although this coincides with the hierarchical structure of the centre–periphery framework, it does not imply predominance of any one level over any other. The emphasis throughout our analysis is that certain types of institutions have particular advantages in producing certain types of technology. However, innovation — whether in the "hardware" itself or in the broader context of the knowledge systems or political, social, and economic conditions in which it is applied — is occurring at all levels.

Flows of technology and information and the corresponding volume of SSAAR studies tend to be stronger from left to right in Fig. 1. In the private sector, feedback is moderately strong between clients and the manufacturers that do not have strong international inputs (e.g., manufacturers of farm equipment). Feedback is weaker where the private sector within a developing country serves more as a sales agent for the products of international corporations.

In all events, the private sector sees feedback as an important instrument in "getting the product right." Similar sentiments are expressed by NGOs; their participatory and decentralized methods of working are, in principle, highly conducive to feedback. In practice, however, little detailed SSAAR has been conducted on the strengths and weaknesses of feedback at various levels and among different types of institutions. Studies that have been conducted report that feedback is weak between extension and research in the public sector (see Kaimowitz 1990) and between national and international research centres. However, more detailed studies are necessary to understand better why feedback is weak and what can be done to strengthen it.

In general, "feedback" flows are simply reactions to technology received by the user, or wider information that has implications for the research agenda of institutes at other levels (e.g., on the difficulties or

opportunities faced by the user, or on aspects of user knowledge). The framework requires that one explicitly consider of flows of this kind. Therefore, it builds on concern expressed by many analysts that the conventional transfer of technology models, and the institutional roles they imply, are not suited to understanding multiple sources of innovation and processes of diffusion (Rogers 1983; Clark 1987; Biggs 1989a).

## *Stage 3: An Historical Dimension*

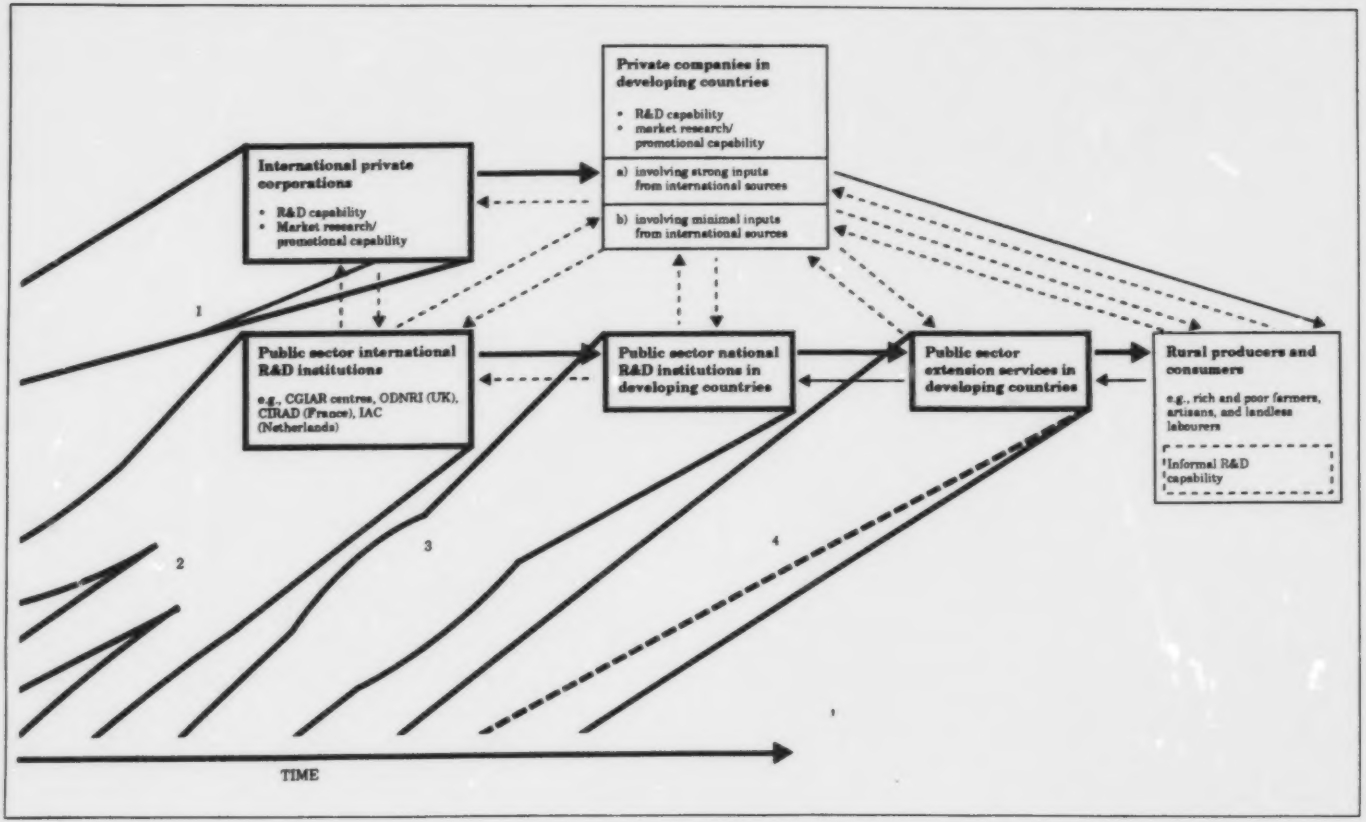
The framework of institutions and interactions between them presented in Fig. 1 is essentially a snapshot. Even though this framework is an important part of the context in which technology is generated, it remains incomplete without considering the historical changes occurring in institutions and in the relations among institutions.

To superimpose an historical dimension directly onto Fig. 1 would make it difficult to interpret. For simplicity, the historical evolution of some institution types from Fig. 1 is presented schematically in Fig. 2. This demonstrates only *some* of the possible historical trends for a *subset* of institution types. Nevertheless, it illustrates how, for instance, many of the international agricultural research centres drew on a variety of resources at national or regional levels (whether technologies, methods, staff, or physical infrastructure) when they were first established. The debt owed to these resources has rarely been acknowledged in published literature from the international centres.

Other trends that can be illustrated include the "mix" of technologies researched within particular types of institution. With advances in biotechnology and changes in the regulatory framework, for instance, MNCs have found it profitable to invest in plant breeding, previously the preserve of the public sector. This has required some redefinition of the public sector's role, leading, in some cases, to institutional change through privatization, for example, and opening up several new areas for SSAAR.

The range of activities undertaken within an institute is also subject to change over time. This results when, for example, the balance between teaching and research changes in a university.

By explicitly considering such changes, Fig. 2 clarifies the context in which particular technologies have evolved, and reduces the risk that attempts will be made to introduce them out of context. It represents an advance over earlier treatments of temporal factors, such as those classifying SSAAR into ex-ante and ex-post studies (Biggs 1983b). Ex-post studies have conventionally evaluated the diffusion and adoption of technologies, the constraints to adoption, the extent of international transfer of technologies, theories of the process of research, etc. Ex-ante studies are often concerned with future


Private companies in developing countries
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e.g., CGIAR centres, ODNRI (UK), CIRAD (France), IAC (Netherlands)
Public sector national R&D institutions in developing countries
Public sector extension services in developing countries
Rural producers and consumers
e.g., rich and poor farmers, artisans, and landless labourers
Informal R&D capability
1
2
3
4
TIME

*Fig. 2. General framework for classifying SSAAR, with an historical dimension. 1, shift in activity as a result of privitization; 2, diversity of origins of international centres; 3, expansion/contraction of national institutions based on funding; 4, shift in the functions of extension.*

prescriptions for national research policy, research resource allocation, and the organization and management of research.

There is a drawback to separating ex-post from ex-ante studies. It discourages analysis of the circumstances under which elements of ex-post studies are selected to support one set of future policies and strategies rather than another. By attempting to keep a wide range of historical changes in view, both within and among institutions, the framework presented in Fig. 2 encourages researchers and policymakers to make the underlying reasons for their decisions more explicit.

## *Applications of the Analytical Framework*

Before illustrations are given of the ways in which the framework can be used, two qualifying observations must be made. First, Figs 1 and 2 are assembled at a high level of generality. Not all components and flows will be equally relevant to all types of developing-country agriculture. The commercial sector, for example, is less relevant to rainfed, small-farm production in hilly areas than to large, homogeneous, irrigated areas. The framework will, therefore, have to be interpreted and used with care by those planning and managing SSAAR in relation to specific contexts.

Second, although the typology presented in Fig. 1 is reasonably discreet, it does not represent a "closed" system. It must be viewed in a wider context in which, for instance, political factors and environmental considerations come into play. These form the wider fabric into which the actions of all types of institutions are interwoven, providing points of reference for research managers determining future SSAAR priorities.

This wider context is subject to shocks that affect SSAAR decisions. For example, increased concern for the environment has led to stricter control over the registration and use of agrochemicals. Consequently, the regulatory functions of public-sector agencies in this sphere have increased. Similarly, and as previously mentioned, public sector involvement in biotechnology (e.g., plant breeding) has increased as a result of private sector involvement.

Given its general nature, users are likely to adapt and build upon specific aspects of the framework in relation to local circumstances. Several examples of how future SSAAR priorities can be derived from the framework are provided in Chapter 4. In the remainder of this chapter, two examples are described. They illustrate ways in which the overview provided by the framework of institutions, the actual or potential linkages between them, and their interaction with the rural clientele provide insights that depart somewhat from conventionally held views. The first example concerns identifying of the rural clientele. The second concerns identifying research methods and their institutional implications for technology development under difficult farming conditions.

## *Characteristics of the rural clientele*

The premise on which most agricultural technology development is based is that the ultimate client is the farmer (e.g., CIMMYT 1988; Merrill-Sands et al. 1988). There is little doubt that farmers are the most important category of clients, both numerically and in terms of potential productivity gains through the adoption of new technology. However, Ewell (1988) found when poorer groups of farmers in a community were identified as the proposed clients, richer farmers were the main participants in the program. Increasingly, research managers are developing methods to ensure the full participation of poorer farmers (Sutherland 1987; Kean and Singogo 1988). However, the focus on farmers tends to obscure the significance of six other groups in the rural community: agricultural labourers, artisans, traders, consumers, rural women, and the rural community itself.

### *Agricultural labourers*

In many Asian countries, agricultural labourers make up a significant portion of the rural population. In Bangladesh, for instance, 30% of agricultural households are those of labourers, and this percentage is increasing. In many countries, the productive employment that this provides is inadequate to employ a significant number of labourers, even in the long term. This would remain true even if macroeconomic policies were changed to support the development of labour-intensive rural and urban industries (Birdsall 1985). As a result, increased agricultural production by improving labour-intensive technology must become a major government goal. To provide improved technology for such a strategy, agricultural research needs to be oriented toward the problems and needs of landless labourers.

In the agricultural research and farming systems literature, there is a notable absence of projects and programs that have focused on landless men and women as clients. A notable exception to this is the work of the Bangladesh Rural Advancement Committee (BRAC) and PROSHIKA, also in Bangladesh. These large NGOs have been conducting action research on developing a new institution where landless labourer groups own irrigation equipment and sell water to farmers (Wood 1984; Choudhury 1989). A review of IRRI's R & D program on small-farm paddy threshers gave clear results. In the Philippines, the technology resulted in little or no increase in overall productivity, but allowed richer farmers to replace labourers with machines. The same innovation, when introduced into a region of Thailand, did not have this negative effect. There was little labour displacement and the machine enabled small-scale farmers to break bottlenecks and increase productivity. Although there is considerable literature on the effects of mechanization in developing countries, there is a major lack of attention and research methods designed to help agricultural engineers make the interests of landless labourers a major objective of their efforts (Harrison et al. 1988).

### *Artisans*

Artisans are often highly responsive to farmers' requirements for new or modified tools and machinery. In India, Basant (1987) documented the interaction between farmers and artisans over modifications to equipment as a result of changes in plant type and spacing. Unfortunately, literature on this theme from other locations appears to be extremely scarce. Yet, artisans may prove to be an important point of contact for external technology-generating agencies. They could function in much the same way as farmers (in the participatory mode) do in the diagnosis of problems and the design, evaluation, and dissemination of technology. Kinsey and Ahmed (1983, 1984) have shown how a lack of attention to artisan's problems and requests have led to severe restrictions on the development of appropriate agricultural equipment in Africa.

### *Traders*

Traders do not simply buy crops from, or sell inputs to, farmers. Much socioeconomic literature has analyzed the relations into which traders enter with farmers involving the supply of credit (and, occasionally, farm inputs) linked with crop offtake. Much of this literature has, however, focused on the extent to which such relations are exploitative and lead to long-term farmer indebtedness.

At a different level, socioeconomic studies of technology marketing have tended to focus on the organizational problems faced by manufacturers and dealers in reaching small, remote farms (e.g., Jain 1986). Only a few studies have recognized the potential of traders as agents of technological change. For instance, at the Institute of Development Studies, University of Sussex, a conference was organized in 1975 to explore ways in which North-based suppliers could contribute to increased productivity in the small-farm sector through better provision of "new technology" inputs, particularly agrochemicals. Such initiatives are, however, best focused on traders in developing countries who have stronger grass-roots contact with farmers.

This focus is incorporated into the Asia-wide Network on the Users' Perspective with Agricultural Research and Development (UPWARD), initiated in the Philippines in 1989. So far, however, little SSAAR attention has been given to the conditions under which traders may be powerful positive agents for socially desirable technical change. In health and family planning services, the concept of "social marketing" is widely accepted as a socially acceptable method for promoting new information and technologies. Many aspects of the UPWARD approach were foreshadowed in work conducted for the Population Council 10 years ago (Zeidenstein 1980).

### *Consumers*

There is a potentially negative consequence of the farming systems approach to technology development. That is, in focusing attention on preharvest technologies, some of the important influence of consumer

preference on technology selection is lost. Breeding programs at many publicly funded research institutes do, however, screen their material for characteristics such as palatability, processing, and storage qualities. Characteristics such as these are more likely to be captured adequately where, as at CIP, the approach to technology development is explicitly one of *food* systems rather than *farming* systems. Of the growing SSAAR literature in the food systems context, a substantial part draws attention to the gender impact of technologies at the postharvest level (Greeley 1986; Maxwell 1986a; Grosvenor-Alsop 1988). Such effects are implicitly recognized in those agencies focusing on postharvest technology development (e.g., Overseas Development Natural Resources Institute, ODNRI), but little of this work has been subject to SSAAR analysis.

### *Rural women*

The role of women in production, maintenance, and household reproduction has recently been the focus of substantial research (e.g., Moock 1986). Particular efforts have been made to understand how agricultural research can cater to the needs of women farmers (Jiggins 1986; Poats et al. 1988). This is a particularly pressing issue in difficult farming areas where the involvement of women in farm work is highest.

### *Rural communities*

Rural communities are responsible for maintaining the productive resources that are not individually owned, such as forest and grazing lands. Some of the SSAAR literature in this area is reviewed in Chapter 2. As population pressure increases, the need for policy studies on more effective group organization and the management of common property resources becomes particularly urgent (Jodha 1985).

### *Conclusion*

What emerges very clearly from an analysis of the rural clientele for technology development is that, crudely, two types of rural situation exist.

First, in areas of high agricultural potential — where water supply is assured and agroecological conditions are homogeneous — social and physical infrastructures are generally good and farmers are articulate, well-organized, and politically powerful. In terms of our general framework (Fig. 1), linkages from international R & D to national research and extension systems are likely to be strong, and both the research and the institutions conducting it are likely to correspond to the "demand–pull" from the farmers. If conventional linear models of technology are at all relevant to developing countries, it is here that this relevance will be found. When improved technology was transferred to farmers in this way, there was frequently major support from government policy in the form of subsidized inputs and credit as well as guaranteed prices and markets (e.g., India, Indonesia).

Second, in areas variously described as marginal, remote, and low

potential, agroecological and socioeconomic conditions are highly variable, and physical and social infrastructures are poor. Even though some large-scale farming is undertaken in these areas, the majority of the rural population comprises small-scale farmers and labourers whose political strength is generally low. These farmers are unlikely to pull either general development policies or R & D agenda toward their needs and opportunities.

Two important implications arise from the second situation. First, the highly variable conditions, high levels of "systems" interdependence, and low integration into the market are likely to render technologies developed at the international level and passed through national systems largely irrelevant. Second, the complexity and variability of these environments, together with the limited capacity of farmers to articulate their needs and opportunities, is likely to limit the extent to which these farmers can create demand–pull on the research system. As a result, "institutional response," whether through prices or direct pressure, is likely to be limited.

In summary, literature dealing with the opportunities and needs for new technology among "resource-poor" farmers has focused on issues such as how, in collaboration with farmers, to identify research priorities and to test, evaluate, and disseminate new technology. This literature fits broadly into the right-hand side of the general framework presented in Fig. 1. It focuses on the links between clients and NGOs, and between clients and national research and extension services. To give adequate attention to this important area of technology development — which departs substantially from linear technology-transfer thinking — the next example outlines a farmer participatory subtypology. This may be regarded as an expansion of one area of our main framework.

## *Research methods and institutional implications for difficult farming conditions*

### *Background*

In Chapter 2, we discussed the strengths and weaknesses of the mainstream "technology-transfer" literature in relation to developing countries. In doing so, we highlighted the need for a closer incorporation of institutional considerations into the R & D process than that postulated in, for example, the induced institutional innovation model, if adoptable technologies are to be developed.

The notion that research institutions respond to farmer demand is more strongly challenged the further one progresses from the homogeneous, well-endowed areas of agriculture into the "peripheries" of difficult farming conditions. The resource-rich areas are likely to hold the majority of rural political power and have adequately operating markets. Difficult farming areas are characterized by high variability in time and space, low and erratic rainfall, poor soil, hilly topography,

heavy reliance by farmers on a wide range of interacting components of the farming system (in, e.g., fodder production), weak communications, low densities of formal R & D services, and low per-capita income. Mellor (1988) estimates that, of a global total of 550 million people living in rural poverty, 300 million live in these areas of low agricultural potential; others have argued that 1 billion is a more realistic number (e.g., Chambers et al. 1989). The diverse and difficult conditions of such peripheral areas make agricultural R & D a complex and costly process. Two broad sets of implications have been drawn in the literature.

One approach is to view variations in resource endowments within low-income countries in the context of a global abundance of food, arising largely from surpluses generated in the United States and Europe. Mellor (1986) argues that these surpluses are likely to persist for some time and, if properly managed as food aid, offer the opportunity to reduce population pressures in areas unsuited to sustained, arable agriculture. Populations should be induced to move to better endowed areas, where the potential returns to agricultural research are high and where research should, therefore, be focused. Taxes on the resultant increase in agricultural productivity could finance a secondary level of research on sustainable systems (likely to centre on pastures and perennial crops) for the poorer, more fragile environments.

The implications for research methods and institutions of Mellor's (1986) position are broadly captured by the current mainstream literature on technology transfer. That is, with some adaptation by developing-country research systems, technologies developed in the North or at the IARCs might be widely adopted within homogeneous, well-endowed areas of developing countries. The types of agrochemical and mechanical technologies promoted by private companies are likely to be widely adopted there. Also, developing country R & D institutions can be expected to be sensitive to the demand–pull of producers in these areas.

A second view is illustrated in Chambers and Ghildyal (1985). Although noting the successes of agricultural research directed toward well-endowed areas (such as the Indian Intensive Agricultural District Programme), they question the extent to which the benefits from these (in terms of research findings, research methods, or generated wealth) will "spill over" to poorer areas.

This position implicitly challenges two basic premises: that developing countries can manage the major intersectoral adjustments proposed by Mellor (1988) and that the progressive tax being proposed can actually be implemented. This view also questions whether research in well-endowed areas can generate enough employment to make a significant impact on populations in resource-poor areas. In fact, Mellor (1988) has subsequently modified his earlier position, calling for agricultural research to embrace the rural poor, in areas of both high and low potential.

Many observers have become increasingly concerned that

conventional research methods are ill-adapted to the needs of difficult farming areas. Some are beginning to draw out the institutional implications of the innovative research methods being developed. This section is concerned with the methods and institutional arrangements for technology development for resource-poor farmers operating under difficult conditions.

### *International work on farmer participation in research*

There has recently been an increase in international interest in studies that directly or indirectly address issues of farmer participation in research (e.g., Chambers et al. 1989; ILEIA 1989). The topic has also been the subject of some of the networking activities of the Farming Systems Support Project (FSSP 1987). As early as 1980, CIP issued circulars urging the involvement of farmers in research (CIP 1981a). The Agricultural Administration (Research and Extension) Network of the Overseas Development Institute (ODI) has published reviews and issued discussion papers on this topic (e.g., Ashby 1987; Box 1987; Rhoades 1987; Basant 1988; Farrington and Martin 1988; Sagar and Farrington 1988; Starkey 1988; Thiele et al. 1988). Farmer participation is a major theme in a book on indigenous technical knowledge (Richards 1985) and of a 1988 issue of *Experimental Agriculture* (volume 24, number 3).

Many writers have argued that farmers have a potentially important role as researchers (e.g., Richards 1986; Rhoades 1987; Gupta 1988). Biggs and Clay (1981) outlined the characteristics and potential of both formal and informal research systems. What emerges from these writings (and others in Appendix 1, theme 15) is that, particularly in difficult and highly variable farming conditions, neither a formal nor informal R & D system alone is likely to be the optimal vehicle for technology development. The advantages of each must be combined if R & D is to be efficient. However, defining the interface between formal and informal systems is likely to be a largely empirical process, depending strongly on individual circumstances (Chambers et al. 1989: 24–30).

Figure 3 illustrates the relationship between formal and informal R & D. The framework defines four groups of actors and the linkages between them. The arrows illustrate the two-way transfers of information, knowledge, and technology. The left-hand box represents scientists in institutionalized agricultural R & D systems and researchers who are trained in formal methods of scientific inquiry. The right-hand side represents farmers and other people in rural areas who are the "clients" of the formal R & D system. The shaded informal R & D box indicates resource-rich or resource-poor farmers who are "research minded." They generally have no formal training in scientific methods but experiment in ad hoc and systematic ways (e.g., Biggs 1980a; Brammer 1980; Richards 1986; Ashby 1987; Box 1987; Rhoades 1987). The continuing use of local varieties and the many production and consumption management practices used by people in risky, resource-poor environments illustrate the importance and continuing

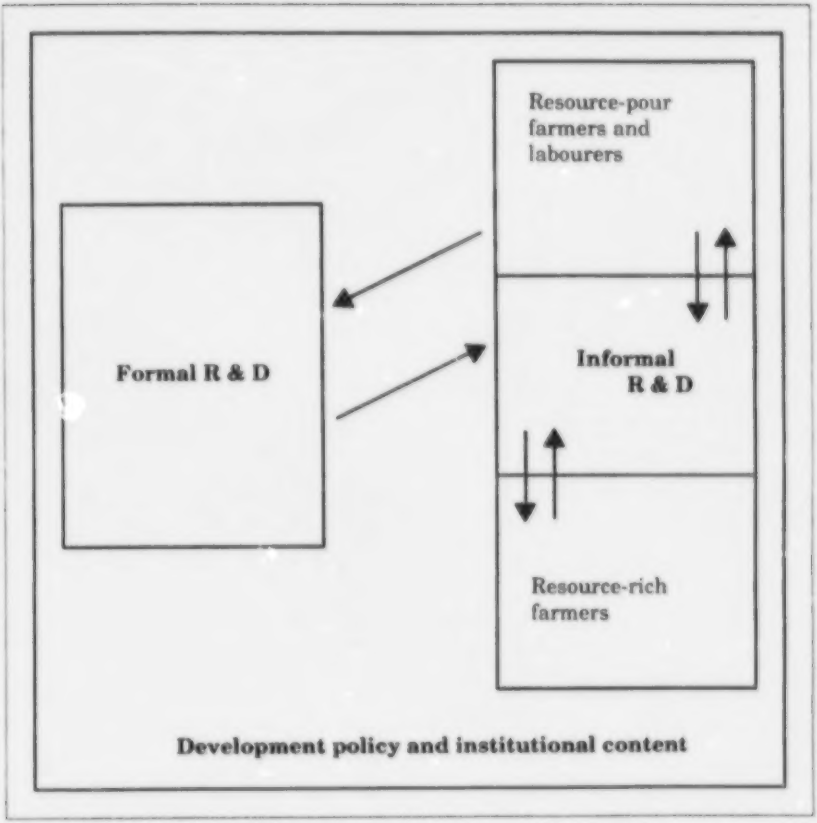


*Fig. 3. Linkages between formal and informal agricultural R & D systems and farmers (source: adapted from Biggs 1989b).*

viability of this informal R & D (for a full description, see Biggs and Clay 1981).

This framework suggests many topics and linkages, for example,

- the informal R & D process of farmers,
- how technology is transferred within the rural production and consumption systems by "informal" extension systems,
- whether some informal R & D farmers have problems brought to them, and
- whether there is informal "community" research.

The literature on informal research and diffusion processes is very thin. A notable exception is a study by Green (1987) that traces the spread of Pokhreli masino rice, a local variety in Nepal. In this case,

farmer-to-farmer exchanges within an ethnic group were important features in understanding the diffusion process.

On-farm and farming systems research (FSR) literature has always emphasized the involvement of farmers in the research process, whether through farmer participation, collaboration and involvement, or talking to farmers about their needs, problems, and reactions to technology. Most of the literature and activities have been directed at the problems of resource-poor farmers. This was in response to the many research and extension systems that were organized and managed to meet the needs of resource-rich farmers. However, even though the need to work with resource-poor farmers was recognized, there has been a wide divergence of opinion over central issues of farmer participation. These include the type of participation, the purpose, and the timing in the research process. To analyze these issues, four modes of farmer participation in research were described in a recent ISNAR study (Biggs 1989b), which built upon earlier work done at the International Center for Tropical Agriculture (CIAT) (Ashby et al. 1987).

- *Contract*: Scientists contract farmers to provide land or services.
- *Consultative*: Scientists consult farmers about their problems and then develop solutions.
- *Collaborative*: Scientists and farmers collaborate as partners in the research process.
- *Collegiate*: Scientists strengthen the independent informal R & D systems in rural areas.

The modes are distinguished by differences in objectives and by the organizational and managerial arrangements required for implementation (Table 3).

This typology was used to analyze case-study material collected from nine countries under the OFCOR program (Merrill-Sands et al. 1989). The study found the framework to be strong from several perspectives.

First, it provides guidance to research managers in several areas. For example, in research methodology, testing varieties under a range of agroecological conditions requires only contractual collaboration. However, meetings designed to strengthen farmer experimentation and the local, informal R & D capacity must be conducted using collegiate methods. At a different level, the typology encourages managers to identify more clearly the political, institutional, and resource contexts in which research methodology innovations have been made elsewhere before attempting to introduce the innovations into their own systems.

Second, the typology clarifies the dangers of bias in farmer selection and the roles of local politicians, community representatives, and staff of extension and development agencies. It also highlights gaps in the processes of participation. For example, with rare exceptions (see Thiele et al. 1988), participation by resource-poor farmers has only been achieved at the farm and village levels (Biggs 1989a).

Table 3. Participation of farmers in research: distinguishing features of four modes.

| | Contract | Consultative | Collaborative | Collegiate |
|---|---|---|---|---|
| Type of relationship | Farmers' land and services are hired or borrowed (e.g., the researcher "contracts" with farmers to provide specific types of land) | There is a doctor–patient relationship: researchers "consult" farmers, diagnose their problems, and try to find solutions | Researchers and farmers are partners in the research process and continuously collaborate in activities | Researchers actively encourage the informal R&D system in rural areas |
| Research emphasis | Testing and verification of technology | Surveying and diagnosis, testing and adaptive research | Learning from farmers to guide applied and adaptive research | Understanding and strengthening informal R&D |
| Interaction over time with farmers | Variable | Determined by stages of activities (i.e., diagnosis, design, development, verification, diffusion, and monitoring) | Continuous specific emphasis of activities each year, depending on joint researcher–farmer diagnosis of local circumstances | Variable |
| Types of farmers involved | Those who can guarantee the conditions of the contract | Representatives of the client group (which is defined by scientists) | Representatives of client groups (which are jointly defined by scientists and farmers and change over time) and research farmers | Research farmers from the informal R&D system |

*(continued)*

Table 3. Concluded.

| | Contract | Consultative | Collaborative | Collegiate |
|---|---|---|---|---|
| Who "speaks" for the resource-poor farmers in the research process | Views and opinions of farmers are not emphasized | Field-level staff, social scientists, and local representatives | Themselves, research farmers, local representatives, and junior and senior scientists | Themselves |
| Emphasis on extension/ development | Variable | Research aimed at extension target areas or recommendation domains | Variable | Strengthening the integration of informal research and extension capabilities |
| Priorities in on-farm research programs | Trials and written reports | Informal surveys, trials, formal surveys, reports of researcher analysis, and field days for extension purposes | Village research legitimacy meetings, meetings for diagnosis, planning, and interpretation, trials, and formal surveys | Supporting research farmers and research-minded local representatives and politicians, and information networks for resource-poor farmers |

Source: Biggs (1989b).

Overall, the typology is likely to stimulate clearer thinking on how the research environment (whether institutional, political, or resource related) must change if participatory methods are to be widely introduced.

# *Chapter 4*

# *Areas of High Payoff for Future SSAAR*

With few exceptions, such as biotechnology and soil and water conservation, it is difficult to predict where research resources in the *natural* sciences will be allocated over the next decade. Inevitably, part of the SSAAR agenda will be influenced by trends in the natural sciences. However, our primary purpose here is neither to predict such trends nor to discuss the SSAAR "response." It is, rather, to suggest SSAAR priority areas in a more general vein. In doing so, we draw on both the review of SSAAR literature in earlier chapters and on the framework developed in Chapter 3. Our views on priorities are inevitably subjective. Nevertheless, they demonstrate some of the insights provided by the framework and, at the very least, will serve as a basis for discussion.

The particular advantages of the framework presented in Figs 1 and 2 are twofold. First, decision-makers in resource allocation are explicitly reminded by the framework of the other types of agencies involved in technology development. Second, they are reminded of actual and potential interactions among institutions. Three broad groups of decision-takers can be identified:

- research managers in the public sector,
- administrators and advisers in voluntary agencies, and
- individuals or institutions involved in "independent" SSAAR (see Chapter 3).

Although the commercial sector is represented in the framework, and its managers occasionally commission studies that have social science components (e.g., market surveys), work of this kind tends to be governed by the profit motive. Although profit is related to productivity, it rests on a much narrower set of criteria than those of maximizing net social welfare, which have underlain our discussion throughout. Furthermore, much of the commercial sector activity in any developing country is international in character. So, any SSAAR initiated by the commercial sector is likely to have been based on criteria determined in metropolitan centres. It may, therefore, be of limited relevance to individual developing countries.

For these reasons, future priorities for any SSAAR initiated by the commercial sector are not considered here. It is, however, important for

research managers in other sectors to account for the activities of the commercial sector when planning their own research, whether in the natural or social sciences. The activities of the commercial sector will also remain an important area of investigation by independently initiated SSAAR. Examples of both directed and independent SSAAR on the commercial sector arise in the discussion that follows.

Two broad considerations will guide the discussion of SSAAR priorities:

- What areas have been over- or under-researched by SSAAR in the past?
- What future developments in agriculture are likely and what requirements will they pose for SSAAR?

A substantial part of future SSAAR directed by research managers will address issues that have already been the subject of extensive research. This does not imply an allocation of scarce research resources into areas of diminishing returns. Nor does it imply a duplication of work. Rather, it suggests the exploration of how wider issues of technology, institutions, and methods relate to local conditions, and the development of local adaptations and approaches to suit these conditions.

Many of these issues correspond to the thematic headings in Appendix 1. They include, for instance, five themes under which almost all of the 1 000 references cited in this book fall:

- diffusion, adoption and constraint studies (theme 1),
- socioeconomic consequences and impact studies (theme 2),
- resource allocation in formal R & D systems (theme 3),
- studies on field-level research methodology (theme 12), and
- public-sector international research policy and planning (theme 13).

In many countries, very few social scientists are engaged by national research services to investigate issues of this kind (e.g., India — Coulter and Farrington 1988). Therefore, if recruitment increases, the volume of work in these areas is bound to grow.

Similarly, much future SSAAR in the international public sector will expand upon current research areas. For many of the IARCs, these areas will include those in the preceding list. For example, ISNAR, an IARC that concentrates on management methods, will continue to work on exploiting the comparative advantage of an international centre in assembling information on how management is practiced in specific contexts and on drawing general lessons. In the following discussion, we outline specific themes that offer high future payoff to SSAAR. Also, where possible, we specify the type of research manager to which the theme is likely to appeal.

## *Diagnosis and Feedback Studies*

Figure 1 indicated the low priority given to diagnosis and feedback studies. We distinguish between diagnosis and feedback at two levels: first, between the end users of technology (whether farmers, artisans, or landless labourers) and national, public-sector research and extension services and, second, between national and international agricultural research services.

### *End-user feedback*

In many developing countries, the research agenda has neglected the needs of the majority of rural people seeking livelihoods in difficult farming conditions. This has been a major concern of several analysts (e.g., Chambers and Ghildyal 1985; Chambers and Jiggins 1987a; Rudra 1987; Farrington 1988). Yet, there has been little systematic effort to obtain feedback from farmers on the technologies developed. Major studies on client-oriented research (e.g., Ewell 1989) confirm that feedback has rarely been sought by scientists. Any efforts have been haphazard and weak. Wide-ranging studies on research–extension linkages have arrived at similar conclusions (Seegers and Kaimowitz 1989).

Feedback between farmer and national research services may be impeded by inappropriate systems of technology dissemination. These systems often have an administrative hierarchy separate from that of the research. In this respect, the wisdom of applying a uniform approach to extension, such as the Training and Visit system (T & V), across diverse contexts has often been questioned.

Until recently, few studies have analyzed when and why feedback actually occurs and how shortcomings might be overcome (Biggs 1980b, 1983b; Rhoades and Booth 1982; Merrill-Sands and McAllister 1988). Several analysts, including Chambers and Ghildyal (1985) and Gupta (1987b), have argued convincingly that the root of the problem lies in differing perceptions by scientists of to whom they are accountable and for what. Some scientists insist that their role ends with the publication of results, that they are accountable only to their administrative hierarchy for the competent conduct of experiments, and that published work forms a major criterion of performance. These researchers will have limited interest in obtaining feedback from farmers, particularly feedback indicating the types of additional work required if technologies are to be accepted.

If such difficulties are to be overcome, research managers must take vigorous action on several fronts. They will need to direct detailed studies of not only the outcomes of specific research but also whether the research was sufficiently user oriented as it progressed from initial proposal, through its conduct, to the implementation of results. If thoroughly conducted, such studies could form a basis for discussion

among scientists of the constraints they face in orienting their work more fully toward clients.

Two preconditions exist for work of this kind to succeed. First, scientists could feel threatened by the implication that their work is being too closely "reviewed." Sensitive approaches are necessary. They must have the explicit support of research managers and the scientists involved must play a major role. Second, methods of "responsiveness assessment" must be developed to suit local conditions. The depth of local knowledge that is necessary implies that such work is the preserve of developing-country researchers, not international institutes or individuals.

Participatory research requires not only "feedback" from farmers but also assessments of how far, and under what conditions, farmers have

- developed their own capacity for experimentation and dissemination and
- been able to influence the research agenda of the public sector.

Some advances in these areas may result from NGO activities. In other cases, advances can be made by grass-roots organizations or by loose groups of individuals. Green (1987) provides one of the few discussions of such innovation. More in-depth analysis is needed in this area if public sector's research agenda are to become more client responsive.

## *National and international research centres*

Little has been written on the role of feedback between national and international research systems. Such feedback should ensure that research agenda in international centres are compatible with the needs and opportunities of national centres. Indeed, the main reason for establishing ISNAR as a link between the IARCs and national services was to strengthen national services so that they would be better equipped to *receive* and act on technologies transmitted from the IARCs. A conference held in the late 1970s on the communication responsibilities of the IARCs concentrated almost exclusively on issues of how to transfer information from centres to national programs (ADC and IRRI 1980). No attention was given to issues of how information from national systems could effectively influence the research agenda of the centres. Although the IARCs now claim to be responsive to the needs of national programs, there appear to have been no systematic studies in this area.

Conversations with scientists from many developing-country research programs — particularly those focusing on plant breeding — indicate that this is a major area of concern. Scientists often feel overwhelmed by the programs of "collaborative" trials of genetic material set up by international centres, sometimes without adequate consultation with developing-country scientists. These trials consume scarce resources and, in many cases, are of little benefit to developing-country programs.

Farrington and Mathema (1990) detail the incorporation of genetic material from international centres into improved varieties of food crops released from the mid-hills of Nepal. They find the proportion of "international" genetic material to be very low, despite collaborative programs with two international centres that have been running for over 10 years. Consequently, two steps have been taken by research centres in Nepal. An independent consultant has recommended that such collaborative trials be conducted less frequently and on a reduced scale. More radically, the two major mid-hill research stations are turning increasingly to small "niches" of local cultivars as a major source of germ plasm for breeding programs. These cultivars exhibit many of the characters sought by farmers. Local rices, for example, have been found to perform adequately at over 2 000 m, where practically all the material obtained from international sources suffered cold-induced sterility.

Accounts have been given of the failings of international centres to respond to the requirements of national centres. They cover not only the inappropriateness in the scale and type of collaborative trials but also the inadequate training of developing-country scientists in specifying the characteristics of the genetic material sought. If the programs of international centres were sufficiently "participatory" in the sense of soliciting clearly specified *demands* from developing-country scientists, giving continuing and detailed assistance in how to formulate such demands, and responding to them, some of these shortcomings could be identified and overcome by frequent monitoring. The troubling feature of such shortcomings is not simply that they continue to exist, but that they are the subject of complaints by developing-country scientists only in local media or internal reports.

Inadequate training and limited confidence among developing-country scientists have some bearing on these issues; however, their origins lie in the fundamentally unequal relationship between national and international centres. International centres control the allocation of funds for training courses, consultancies, and participation in international conferences by developing-country scientists. Consequently, these scientists tend to avoid overt criticism of services provided by the IARCs.

Sensitivity to such issues would stimulate a proactive search by IARCs for shortcomings in their relations with national centres. However, there is little evidence of this. Reports published by the international centres contain virtually no reference to ways in which, for instance, their breeding programs have responded to the stated needs of developing-country scientists. Nor does this literature give any hint that it is a priority of the IARCs to stimulate a stronger demand–pull on their services. This is potentially a major area of concern, particularly in view of claims that plant breeders in Bangladesh and Sri Lanka who disputed the relevance of IRRI's breeding strategy were subsequently starved of resources (Anderson et al. 1990). If the international centres' hierarchical perception of technology generation and diffusion prevents them from investigating these issues, then research managers in

developing countries should commission such work. In any event, a less egocentric view by the international centres and a less deferential posture by the national centres would undoubtedly produce gains in this area.

## *Issues Relating to Voluntary Agencies*

The analytical framework in Fig. 1 suggested that two aspects of voluntary agencies have been widely underestimated:

- their role in developing and disseminating technology and
- the scope for mutually beneficial links between voluntary and public-sector agencies.

Two major reasons for this have been proposed (Farrington and Biggs 1990). One is that NGOs are largely staffed by practitioners who see little direct value in systematically recording their experience. The second reason is the predisposition among many public-sector institutes, at both national and international levels, that NGOs are concerned more with relief than development work; they are seen as lacking necessary professional skills, commitment to long-term presence in specific areas, and any coordination of efforts. Some of these criticisms ring true for some NGOs in some contexts. NGOs are highly heterogeneous in philosophy and practice, in levels of skills and resources, and in capacity and inclination to develop institutional capabilities relevant to agricultural technology.

Evidence is now being published, however, that refutes many of the perceptions outlined above.[6] For example, there are more qualified agronomists at degree and technician levels working with NGOs in eastern Bolivia than with government services (Thiele et al. 1988). The same is reported of Honduras (M. Richards, personal communication). A particular feature of the Bolivian case is the high degree of collaboration (financed by the local development corporation) between NGOs, farmers' organizations, and research services. This has been established on the mutual confidence created through informal contacts over many years. NGOs and farmers' organizations in parts of Ecuador are stronger and more sensitive than government services in providing certain farm inputs and in training (Bebbington 1989). International efforts are underway to strengthen farmers' organizations (see the Newsletter of the International Federation of Agricultural Producers). Feingold (personal communication) is currently preparing a study on their role in promoting technology development and dissemination.

[6] This evidence is being published partly at the instigation of one of the authors (John Farrington), who is leading a study at ODI on NGOs and agricultural technology. This study is particularly concentrating on the scope for wider collaboration between agencies within and outside the public sector in the development and dissemination of agricultural technology.

NGOs in parts of West Africa are participating in seed production and distribution programs for major crops (e.g., Osborn 1990 — Senegal; Henderson 1990 — The Gambia). The Gambian research service has a policy of inviting NGOs to participate in trials programs (Gilbert 1990). In Sierra Leone, NGOs are being invited to participate in a wide program of technology testing and dissemination (P. Richards, personal communication).

Many other examples could be cited. The weight of evidence is sufficient to indicate that analysis — either by NGOs themselves, by independent research, or by public-sector agencies seeking areas of collaboration with NGOs — has failed to do justice to the role of NGOs or to address key questions relating to that role. As the cofunding arrangements of bilateral and multilateral agencies' with NGOs expand, and as institutes promoting major policy interventions take increasing interest in the activities of NGOs (Cernea 1985), the need increases for SSAAR to address such questions. Four urgent questions are discussed here.[7]

## *What is the scope for closer collaboration between NGOs and government research and extension services?*

Closer collaboration between NGOs and government research and extension services could substantially benefit both sides.

The agricultural research and extension service of the public sector stands to gain from

- NGOs' knowledge of local agroecological and socioeconomic conditions,
- the ability of NGOs to articulate this knowledge, or to encourage farmers to articulate it,
- the resulting demand–pull on available technologies or on research agenda,
- a sharper identification of problems and opportunities for research, and
- clearer feedback on the acceptability of technologies.

NGOs stand to gain through

- greater access to technical knowledge, materials, methods, and libraries, all of which are highly specialized and costly and
- the possibility of training for NGO staff and farmers in specialist techniques such as propagation, pest and disease control, and varietal improvement.

[7] Several of these issues are being addressed by the ODI study on NGOs and agricultural technology (see footnote 6).

Over the longer term, NGO efforts may not be institutionally sustainable. Nevertheless, the more enlightened NGOs seek to establish local groups (such as farmers' organizations) that can be financed through membership fees or production levies. Such groups should then be able to influence research agenda, in much the same way as farmers in Europe and the United States did during the early years of institutionalization of agricultural research.

It is possible that the advantages of closer collaboration could threaten the agenda of NGOs. Substantial SSAAR is needed to find the extent to which advantages can be exploited without this happening. Such research must address the following hypotheses:

- *NGOs and government services are complementary in terms of both spatial and client-group orientation.* NGOs prefer to work with poor farmers in remote and difficult farming conditions; government services prefer those areas with better agroecological and infrastructural conditions.

- *NGOs and government services are complementary in research and extension methods.* NGOs are naturally inclined toward participatory methods that encourage local communities not only to have a voice in technology selection and the research agenda but also to develop their own capacity for experimentation. The strengths of government services lie more in providing contact with ideas and technologies arising from research, whether conducted nationally or more widely.

- *NGOs and government services are potentially complementary in research areas.* Casual investigation suggests that public-sector research institutes find it difficult to bring together several disciplines, sometimes from different departments, to focus on complex issues such as the management of soil and water resources or the enhanced provision of fodder. The greater flexibility of NGOs may be advantageous in addressing such issues.

It is clear that, in some countries, the macropolitical climate is unfavourable to NGO activity. In others, NGOs would regard collaboration with government services as the endorsement of a status quo unacceptable to their clientele. Furthermore, NGOs are highly heterogeneous in their objectives and capabilities: although many may exhibit the advantages outlined, some clearly do not (Moris 1988).

For these reasons, NGOs cannot be regarded as a panacea. Nor should the degree of sensitivity required to work successfully with them be underestimated. NGOs have their own agenda and are unlikely to collaborate with agencies that pose a threat to their independence of action.

### *How effective is NGO work in technology development, dissemination, and training?*

Many of the hypotheses outlined under the previous question are also relevant to the evaluation of NGO impact, which is currently the subject of much unsubstantiated assertion. Increased support for NGOs through cofunding schemes, for example, increases the need to know whether they achieve the comparative advantage that is often claimed for them. As previously mentioned, NGOs often work in difficult areas with farmers who have had limited access to outside resources and are often politically marginalized. The extent to which this route is followed affects both the types of technology on which NGOs are likely to work and their prospects of success. Key issues in any evaluation include

- the time scale within which quantifiable impact should be expected,
- what the indicators of "success" should be,
- which indicators should be regarded as quantitative and which as qualitative, and
- what the degree of success has been in absolute terms and in relation to alternatives such as government services, both overall and per unit of expenditure.

### *How successful are the new technologies introduced by NGOs?*

Many NGOs are attracted to the concept of sustainable agricultural development. Therefore, they participate in networks oriented variously toward "ecological agriculture" or "low-external-input agriculture." The types of technology promoted in these include integrated pest management and integrated nutrient management. However, the presentation of these technologies in some NGO newsletters tends to be populist, underestimating both the technical skills and overall labour inputs required. Very few studies have drawn together and evaluated field experience in using techniques of this kind (e.g., ILEIA 1989). Such efforts need to be expanded. In their absence, NGOs may find themselves taking technology routes that, although superficially appealing, do not live up to their promise.

### *How efficient are NGO institutional arrangements for the accumulation and sharing of experience?*

Similarly, NGOs have experimented with various institutional arrangements. The results, however, are not widely available. They include

- requirements of varying rigour for reporting, indexing, and storing information on field trials in an easily accessible fashion,

- employment of expatriate scientists on a project, national, or regional basis, and
- employment of developing-country staff at "barefoot," technical, and graduate levels.

There is a pressing need to draw general lessons from this experience so that "newcomer NGOs" do not waste resources in unnecessary trial and error. The framework presented in Figs 1 and 2 places the work of NGOs in the wider context. Therefore, it can assist in preparing an inventory of NGO research and in identifying future research requirements.

## *Institutions for the Equitable Use of Common Property Resources*

Much of the SSAAR literature of the 1980s on FSR and farmer participation through on-farm research has taken attention away from problems of community or regional use of common property resources. At the heart of much FSR has been the notion of the way *individuals* behave and respond to economic opportunities. In the past, however, the management of common property was an important area of SSAAR. In the future, it will be increasingly important. Already, in the area of irrigation, important studies are underway on how committees manage and maintain scarce resources (Martin and Yoder 1987). Also, there are calls for broader approaches to FSR, including community-level issues (Grandin 1988).

Other priority areas for research on community issues are emerging from FSR projects. These include cases where overall returns to communities' resources might be increased if there were agreements to plant certain crops all at once as a pest control strategy or to control wandering cattle. These are examples of research that could result in beneficial group action.

A third area where historical studies and action research are needed is on the group ownership of mechanized equipment (e.g., irrigation equipment, tractors, and rice hullers). There are important examples of this type of research (e.g., the work of PROSHIKA in Bangladesh — Wood and Palmer-Jones 1990), however, it has been somewhat peripheral to SSAAR studies. It needs to be brought more toward centre stage.

## *Behaviour of Agricultural Research Systems*

Agricultural research managers face many decisions in monitoring and evaluating the performance of their staff. There is, however, a lack of systematic analysis to inform these decisions.

International peer review is widely regarded as one of the most

relevant and objective methods for assessing the performance of those working in natural and social sciences. However, this has slightly patronizing connotations. It is frequently researchers in the North who assess the performance of those in the South, set the criteria by which performance is measured, and urge developing-country scientists to join their institutions and societies.

There is also a more fundamental issue: in all areas of science, those who diverge from orthodox approaches frequently find themselves starved of funds. For instance, from the 1970s to mid-1980s, rice scientists working on rainfed rice for diverse environments in South Asia were neglected by most funding agencies. Their interests were clearly subjugated to the political decision to focus research on irrigated rice. Such resource shifts may be justified where research priorities have been based on objective analysis. However, the procedure is sometimes less than objective, where, for example,

- resource allocations to developing countries are distorted to suit the interests of donors or IARCs;
- principles and procedures relevant to research in the North are introduced to developing-country scientists and distort their resource allocation; and
- developing-country scientists are drawn into collaboration with IARC programs to the neglect of locally oriented work.

Some types of training undoubtedly undermine alternative ways of thinking. For example, some of the IRRI's *Cropping* Systems Network activities in Bangladesh reduced the opportunities for strengthening broader approaches to *farming* systems research among local scientists in the 1970s. In fact, it helped to reduce, rather than encourage, collaboration between agricultural research institutions in Bangladesh.

There is clearly a role for more "independent" studies at two levels: studies examining the philosophy and sociology of agricultural science and others systematically looking at the processes of innovation and diffusion in institutional and technological change. Some studies of both types are reviewed in Chapter 2. A recent innovation are studies of the second type conducted by natural scientists, relating to the research systems in which they work. Gupta (1987b), for example, has reviewed the reasons for the neglect of rainfed areas in Indian agricultural research. Quite apart from their policy importance, reviews of this kind would revitalize the training of agricultural scientists if only they were more widely incorporated into the curricula.

# Chapter 5

# Conclusions

The opening chapter set out the concerns underlying this study. The general purpose was to assess the contributions made by social scientists in the analysis of agricultural research and to identify how SSAAR might best address future issues.

SSAAR has evolved, at the macro level, from early theories of modernization to a growing awareness of the need for compatibility between the pace and direction of agricultural change and the specific political, social, and economic conditions of individual developing countries. At the micro level, a preoccupation with farm-management studies has given way to a wider analysis of the approaches, methods, and institutions relevant to the development and dissemination of agricultural technology. Although still in their early stages, trends of this kind indicate an increasing relevance of social science analysis to emergent issues in agricultural research.

There remain, however, many difficult challenges for SSAAR if it is to serve research managers adequately in the future. These challenges will arise from increasing complexity in three areas:

- the nature of science,
- the difficult farming conditions that research is increasingly called upon to serve, and
- the relationship between productivity gains and the long-term sustainability of the productive resource.

## Complexity in Science

The increasing complexity of science and its relationship to political power is a theme explored by several analysts (Busch and Sachs 1981; Aronowitz 1988; Burmeister 1988; Feyerabend 1988; Richards 1989). Practical evidence for increasing complexity is the burgeoning subdivision of scientific disciplines in recent decades. For instance, what was once the responsibility of a broad-based researcher in plant protection is now divided among plant pathologists, virologists, weed scientists, helminthologists, and specialists in bioassay, pesticide application, pest–predator relations, and pesticide residue analysis, to

name only a few. The role of the research manager — and the demands for advice from social scientists — increase in complexity with this growing specialization.

Advances in science at the cell and molecular levels provide further examples of complexity that will increase the demands on SSAAR. The more fundamental science becomes, the more difficult it is to predict the nature, timing, and incidence of its product. Biotechnology is complex not only in this respect but also in the challenges it poses to the legal framework (e.g., in plant breeders' rights), to the relations between private- and public-sector R & D (e.g., in the increasing privatization of knowledge), to ethics (e.g., with the manipulation and patenting of life forms), and to the environment (e.g., through the unpredicted consequences of genetically engineered organisms).

## *Complexity in Farming Conditions*

Agricultural research in both public-sector and voluntary organizations and at national and international levels is focusing increasingly on small-scale farming in rain-fed environments. This is due to three factors:

- perceived opportunities for productivity gains, which were disregarded by Green Revolution research,
- policy initiatives aiming to reduce income disparities across the farming community, and
- the need for technologies that are both profitable to farmers and protective of the environment (e.g., India 1985).

Rain-fed environments have been described as complex, diverse, and risk-prone (Chambers et al. 1989). They are characterized by low and erratic rainfall, poor soils, hilly topography, diverse socioeconomic conditions, and weak physical and social infrastructures. Under such diverse conditions, identifying technologies appropriate to farmers' needs and opportunities is exceptionally difficult. Participatory methods have achieved some success, but institutional forms are now needed to adapt and implement these methods over wide areas. This will almost certainly require collaboration between a resource-constrained public sector and various voluntary agencies. The conditions for successful collaboration are likely to be highly location specific, requiring detailed work from social and natural scientists.

## *Complexity in Long-Term Sustainability*

Many of the arguments outlined so far also apply to the search for long-term sustainability. Sustainability is already on the SSAAR agenda of many developing countries and will become an increasingly strong criterion by which technologies are screened. Yet, to identify

technologies that are both profitable to the farmer and environmentally acceptable will place substantial demands on both social and natural scientists. In particular, social scientists will have to help identify the type and extent of government intervention needed in factor or product pricing to make environmentally acceptable technologies profitable to farmers.

## *Conclusions*

Social science has demonstrated an increasing capacity in recent years to contribute to the development and dissemination of agricultural technology at both macro and micro levels. In the future, however, the demands on social scientists are likely to increase sharply and the issues with which they will have to deal will become more complex.

From our discussion of complexity, two general propositions emerge on the appropriate role for SSAAR. First, those planning or directing SSAAR must avoid considering individual technology components, institutions, or research programs in isolation from the wider technological and political context. The framework in Figs 1 and 2 encourages explicit consideration of this wider context in two planes: that of the activities and interactions within and between institutions and that of the dynamics of institution-based change over time.

Second, the already inadequate theories of innovation based on demands for technology or technology-generating institutions in response to changes in factor or product prices will become even less satisfactory. For example, SSAAR focusing on biotechnology is more likely to be concerned with relations among institutions (especially between private and public, and private and voluntary sectors) and with the challenges posed by broader legal, political, and ethical issues than with pricing issues. Much the same applies to the analysis of difficult environments, where markets are highly imperfect. In these contexts, although "getting the prices right" remains important, deeper insights into agricultural research priorities, methods, and impacts are likely to be gained through an institution-based approach. It is this type of approach that is proposed in Chapter 3 and explored in Chapter 4.

Finally, despite increasing complexity, three sets of conditions could strengthen the hand of those initiating and directing SSAAR.

The first is a change in the procedures adopted by funding agencies, particularly related to developing agricultural technology for difficult environments. For example, procedures among many international donors are currently too strongly geared to short-term project cycles to be appropriate for difficult environments. They stress short-term expectations, strict disbursement schedules, and highly quantified evaluations based on narrow criteria such as technology-adoption levels. If research for these environments is to succeed, however, it will have to be long term and based on a learning-process approach. Programs, rather than projects, may be a more appropriate vehicle for funding,

incorporating provisions for learning from experience and focusing on long-term institution building. Collaborating institutions should no longer be drawn exclusively from the public sector: donor-funded efforts provide ideal opportunities for collaboration among various institutional types. Outputs, particularly those that strengthen the capacity of local communities to experiment with technology, are likely to be long term and not always quantifiable.

The second is some self-reassessment by international centres. The need to encourage stronger feedback from national research programs was emphasized in Chapter 4 and there is a continuing debate on the role of international centres in information management. However, these are only parts of the overall requirement. A clearer recognition is also needed of the comparative advantages of the international centres. The "centres of excellence" claim is strong when it is applied to basic research on germ plasm; it is weaker when applied to developing institutions and approaches for applied and adaptive research within developing countries. This is not to devalue the excellent work of some centres on these issues; it simply draws attention to the fact that such approaches have been created and developed as much by local innovators as by the centres themselves. The IARCs will never have the resources to become involved in such location-specific work in anything more than a piecemeal fashion. They should

- recognize those local organizations *already* committed to such work (whether governmental or voluntary),
- devise ways of making themselves more supportive of, and accessible to, such efforts, and
- encourage developing-country research services to follow suit.

The third is a more explicit recognition of the political nature of the demand for agricultural technology. Many participatory approaches seek to identify research priorities from poor farmers. However, these farmers must be politically empowered in the broadest sense if their demands on the research agenda are to be sustained on a more profound and enduring basis. Broad empowerment of this kind relies on conditions far wider than those relating to agricultural research, but researchers have an important role to play in two areas:

- in helping farmers articulate a demand on the research agenda through participatory approaches and
- in explicitly recognizing the political nature of demands on science, the avoidance of actions that foreclose options to poorer farmers, the promotion of actions that create access by farmers to research, and the accountability of research to farmers.

# Chapter 6

# Outlying Observations

This chapter highlights four topics relevant to the main arguments of this book. Their exclusion from the preceding text should not be taken to detract from their importance — we discuss them here because earlier inclusion might have distracted the reader from the main lines of argument.

## New Agricultural Research Methods

In recent years, the number of publications concerned with social science inputs into research planning and management has increased rapidly. Examples include the on-farm research manuals of many international agricultural research institutes and the papers from various workshops and research teaching courses at the Institute of Development Studies, Sussex, University of East Anglia, and the University of Florida. In many national agricultural research systems, manuals on methods for cropping systems and farming systems research have been written and circulated for use by local researchers. Many of these manuals have been concerned with ways and means of collecting information from farmers, learning from farmers, promoting farmer participation in research, establishing scientists' research priorities, and developing and disseminating technology.

At the policy level, there have been many new publications in agricultural research and extension including those on resource allocation and cost-effective ways of structuring, organizing, managing, and monitoring systems. These documents are now central to the work of organizations such as ISNAR and have long been the concern of many research managers and analysts (Boyce and Evenson 1975; Oram 1978; Daniels and Nestel 1981; Daniels 1987).

In reviewing this literature, we have noted some issues that have often been sources of contention among different groups. These disagreements could have been avoided if researchers had recognized the practice of science as not merely a technical but also a *social* process. How to manage these continuous conflicts is one of the biggest challenges faced by research managers.

## *Sources of innovative methods*

Advocates of certain methods commonly claim that they are "new." For example, in July 1987, one of the "international" social science research institutes, the Institute of Development Studies in Brighton, England, held a workshop on farmer participation in research. The introduction described many of the techniques as "new" and the practitioners as "the professional pioneers" (Chambers et al. 1989). An historical perspective appears to be lacking from this view. Many of the techniques and methods that are presented as new have, in fact, been used or advocated by natural and social scientists and other professionals for many years.

For example, in Asia there is a long tradition of "action research" (Khan 1971; Castillo 1972) and the ability of farmers to create new technologies and institutions has long been recognized by anthropologists and rural sociologists (Biggs and Clay 1981; Gupta 1989). Also, certain extension agencies have long advocated that scientists should learn how farmers seek solutions to their problems before establishing research priorities of their own (e.g., Verma and Singh 1969; Khanna et al. 1978).

Much could be gained from encouraging young professionals to seek and learn from experiences and lessons of the past. This would involve finding and reading classic studies as well as talking with researchers and others who have had long held a farmer participatory perspective. Often, such people have eschewed personal ambition to remain as middle-ranking research officers with a strong field orientation. Repeated undervaluation of past experience does little to encourage young researchers to learn lessons in this way.

## *New ideas and their acceptance*

A second area of ambiguity in the behaviour of researchers developing and advocating new methods concerns acknowledging the sources of their ideas and methods.

The recent work of Ashby (1987) on farmer participation has been particularly important. It has shown "scientifically in an experimental way" that involving farmers in setting research agenda and in the research process itself is more cost effective than methods in which scientists do not consult extensively with farmers or only interact at predetermined stages in the formal research process. As we have already demonstrated in this book, the *idea* that some farmers do informal research and that formal systems can learn from and interact with farmers has been recognized in many places for a long time. What Ashby has done is to demonstrate this to scientists in a series of *experiments*. In other words, he has used the language of their everyday professional activity. Although some scientists may not have been convinced solely by the deductive logic of involving farmers, others have

acted on this logic without the need for "proof through experiment" (Rhoades and Booth 1982).

## *What are new techniques?*

Some members of the anthropology, rural sociology, public administration, political science, and agricultural economics disciplines, among others, must be surprised that methods and techniques basic to their profession for many years are being characterized as "new" by some recent contributors to the growing literature on research methods. Methods such as group interviews, ethnic histories, key informants surveys, secondary data reviews, transects, maps, chronologies of events, and agroclimatic mapping are just a few examples from the new "menu of methods" of "rapid and participatory rural appraisal" (Chambers 1990).

In this context, it is legitimate to ask whether these methods are new or simply old methods (frequently from anthropology, sociology, and public administration) being applied within agricultural research systems. If it is the latter, than the emphasis on *new* methods is wrong. What has changed is that existing anthropological, rural sociological, and public administrative techniques are being used in a creative way within research systems.

We would argue that a strong disciplinary grounding is essential if students are to distinguish between the use and the abuse of research methods. Some of the leading practitioners and proponents of these old techniques applied in new situations are thoroughly trained in one or more specialized disciplines. Without a disciplinary background, we doubt that short courses for young people in the "new methods" will lead to sustained good use of these methods.

## *Conclusion*

In the light of our "participant–observer" experiences as social scientists in agricultural research and technology-promotion systems, we make a plea for the rebirth of

- *an historical perspective of science* that recognizes the need to learn from history and to understand the political and institutional context in which methods and techniques have been used in the past;
- *a respect for "the disciplines"* — in some places the cult of novelty equates a badly used technique with "traditional disciplinary approaches"; one that is used well is "new" and comes from the innovators;
- *a recognition that there are multiple sources of ideas*, and that it is often difficult to distinguish between what is new, what is old, and what is an attempt to get existing ideas accepted in new situations; and

- *an acknowledgment of the political, funding, and institutional aspects* that define whether old or new methods are used, discounting the belief that there is a shortage of "new" techniques and a need for pioneers and leaders to develop them.

## *"Renaissance Men" and Institutional Response*

In agricultural sciences, specific people have often dominated the literature at given points in time. Recently, for example, these have included Dr Norman Borlaug, who was awarded the Nobel Prize for his plant breeding work in the Green Revolution, and Dr M.S. Swaminathan, formerly Head of the Indian Council of Agricultural Research (ICAR) and Director-General of IRRI. In the social sciences, Aktah Hameed Khan, the Director of the Academy for Rural Development in Bangladesh, has profoundly influenced the way social scientists think about and experiment with institutional change in rural areas. In practically all countries there are similar individuals. However, we have found only a few studies that have looked systematically at the role of these dominant individuals. As Darling (1987, p. 1) notes

> There has been understandable concern over the unacceptably high failure rate of agricultural development projects (ADPs) in Africa. Much of the serious literature tackling the associated problems has concentrated on methodological, logistical or political issues — be they scientific or econometric. Relatively little has been published about the influence of individual personalities on project inception and implementation. Yet the corpus of unpublished folklore concerning certain developers in Africa, confidential reports and *in camera* committee meetings, all suggest that this aspect deserves greater attention, as the role of development pioneers may have been both critical and paradoxical.

These dominant individuals tend to have broad and varied areas of interest. Borlaug (1986, p. 5), for example, says "I have been forced to become an integrator across scientific disciplines." Dr Swaminathan (1988, p. 4) maintains that "to solve field problems multi-disciplinary team work based on a systems approach is a must." Do the research *systems* place a premium on team work, not only among biological scientists but also among biological, physical engineering, and social scientists? Do they help social scientists to play a proactive rather than a reactive role?

In view of their far-reaching visions of science and society, we could describe Drs Borlaug and Swaminathan as "renaissance" men. Their concerns for integration and collaboration in the natural sciences is clear. However, students of science and research managers must ask the question: to what extent have these concerns been taken up by research and production systems? Gupta (1987b) tackles some of these issues in a paper aptly entitled *Organising and managing the poor client oriented research system: Can the tail wag the dog?* In this paper, he reviews the

behaviour of agricultural science in India and its relevance to resource-poor farmers.

How far have the charisma and ethos of "renaissance" men influenced the direction of research and of particular institutes? Did these personalities create and form policy, or were they representative of commonly held views among scientists, government officials, and politicians who worked in the same paradigm? Were changes made to research agenda and institutional structures in response to their views?

How far will "renaissance" men go to ensure that other disciplines (especially in the social sciences) are strongly represented in their technical research systems? Polly Hill (1986), an anthropologist, suggests that professional anthropologists have been excluded from an active role in farming systems research by agricultural economists, who see it as "their domain." There is little evidence that anthropologists and rural sociologists (and even macroeconomists) have been actively included in agricultural research analysis.

The International Potato Center (CIP) in Peru is a major exception to this rule. Over many years, the policy of CIP has been to involve all of these groups in setting research priorities and policies. In Asia; however, none of the international institutes, such as IRRI and ICRISAT, have had major anthropology or rural sociology groups that could influence agricultural research priorities. The same is found in most agricultural research institutions at the national and regional levels.

If the visions of "renaissance" men are to be realized, others must take on the wide range of necessary tasks. These tasks are embodied in a wide range of disciplines, and a major challenge for research managers is to make the institutional changes necessary to allow renaissance ideas to be acted upon.

## *IARCs and Difficult Farming Areas*

Following the successes of Green Revolution technologies, many opinions have been expressed on the role of IARCs in locations where resources and government policies for agriculture were favourable. International concern is increasing for innovations that sustain or enhance the environmental resource base underlying increased agricultural productivity. Also, developing-country governments are increasingly concerned with narrowing the income gap between well- and poorly-endowed areas (e.g., India 1985). As a result, IARCs are under pressures to develop technologies suitable for difficult farming areas. Is this a feasible or cost-effective role for the IARCs?

In the mid-hills of Nepal, the Lumle and Pakhribas agricultural centres have a long tradition of research, dissemination, and training. They have received substantial support from a single donor for over 15 years and have been able to act independently of the public-sector research service in Nepal. Consequently, and atypically, both centres

Table 4. Area under improved crop varieties and contribution of genetic material from IARCs in the four districts of Nepal covered by the Lumle Agricultural Centre.

| | (A) Total cropped area (ha) | (B) Area under improved varieties (ha) | (C) B as % of A | (D) Genetic material from IARCs (ha)[a] | (E) D as % of B |
|---|---|---|---|---|---|
| Rice | 64 760 | 25 900 | 40 | 1 994 | 8 |
| Maize | 60 000 | 33 000 | 55 | 660 | 2 |
| Wheat | 8 694 | 8 694 | 100 | 3 695 | 43 |
| Millet | 184 200 | 9 200 | 5 | 0 | 0 |
| Barley | 1 200 | 540 | 45 | 0 | 0 |
| Potatoes | 1 500 | 600 | 40 | 30 | 5 |

Source: Farrington and Mathema (1990).

[a] The area equivalent of genetic material from the IARCs is derived using the following formula. Under each of the improved varieties, the proportion of land that contains some IARC material is multiplied by the proportion of its parentage made up of this material. The product is then multiplied by the total area planted annually to the corresponding plant type. This procedure ignores the weight of contributions by germ plasm from different sources and is, therefore, oversimplified. Nevertheless, the results broadly indicate orders of magnitude.

have abundant resources, well-trained staff, and are free to deal with external agencies offering promising technologies.

Collaborative trials with IRRI and CIMMYT have been conducted annually for over 10 years, and genetic material has been received for testing from other international centres. Table 4 shows the substantial degree to which improved varieties have been adopted in the four districts covered by the Lumle Agricultural Centre. It also shows that, despite substantial collaborative work with the IARCs, varieties containing their genetic material have been adopted to only a limited degree.

This has resulted in a proposed reduction in collaborative trials with the IARCs. A new crop-improvement strategy would identify local cultivars that perform well in particular agroecological niches. Selected material would then be disseminated to areas with similar conditions.

More importantly, the Lumle and Pakhribas centres are beginning to shift their emphasis from genetic improvement to interdisciplinary, task-oriented research focusing on particular constraints or opportunities. One of the most important of these opportunities is in the enhancement of soil fertility. Others include fodder, women's participation in development, research and extension methodologies, and sustainable low-input technologies.

From this evidence, four conclusions can be drawn:

- The IARCs are unlikely ever to have sufficient resources to develop improved genetic material that is relevant to the range and diversity of agroecological conditions found in difficult areas.
- Local screening of material provided by the IARCs is time consuming and costly; procedures for identifying candidate material must be made more cost effective.
- Substantial local resources — from both research centres and farmers — are needed to test and disseminate improved genetic material.
- Cross-disciplinary and highly location-specific issues are emerging as high priorities for research (e.g., fertility, fodder, methods); given their mandate, location, and resources, IARCs are unlikely to make more than very modest contributions to these research areas in the foreseeable future.

## *T & V Extension and "Central-Source" Thinking*

A systematic consideration of the *functions* of extension and of the range of corresponding *services* lies outside the scope of this book. Approaches to dissemination are discussed in the text only to the extent that they reinforce concepts and practice in research. Thus, in participatory approaches (Chapter 3), particularly those with strongly "empowering" objectives, the testing and dissemination of new ideas are much more closely interwoven than is usually possible in public-sector institutions. In the public sector, research and extension are perceived as distinct functions, frequently located in different institutions.

We digress briefly here to discuss the Training and Visit (T & V) system of extension (Benor and Harrison 1977).[8] Over the last two decades, this system has attracted higher levels of donor funding and public sector implementation than any other. Our purpose here is to demonstrate how it has reinforced central-source, technology-transfer perceptions of research.

Arguments advanced in favour of T & V (Benor and Harrison 1977; Benor and Baxter 1984) include

- its strength as a staff-management system,
- the provision of technical backup through subject matter specialists,

[8] Baxter et al. (1988) note that, between 1965 and 1986, the World Bank funded 460 projects in 70 countries containing an extension component. Of the 361 projects for which an extension method was specified, 162 (45%) used the T & V system.

- regular contact between research and extension and the provision for feedback that these provide, and
- the insistence that the extension service be divested of functions (such as the supply of credit and farm inputs) that divert time from the principal functions of communicating agricultural innovation.

Others have seen distinct disadvantages in some of these features. For instance, Francis and Rawlins-Branan (1987) and Kean (1988) have argued that the credibility of extension services is threatened if they do not take a hand in input supply where such services are otherwise weak. More serious criticisms relate to T & V's hierarchical structure and its lack, in practice, of effective feedback from farmer to researcher.

## *Hierarchy*

T & V is essentially centralist in its philosophy. The system regards research services as the source of all useful innovation, and farmers as the recipients of the wisdom incorporated in technology developed by the public sector.

It seeks to further this technocratic approach by imposing a uniform structure for disseminating technology onto the diversity of political, social, and economic environments that exist in developing countries. As we have argued, this diversity must be considered if the scope for introducing, modifying, and further developing technology is to be understood.

T & V's narrow, technocratic approach has ignored the role that many other types of innovation — many of them institutional (see Chapter 3) — have had, not only in assisting the introduction of technology but also in strengthening the local capacity to experiment and produce new ideas. By its preoccupation with the public sector, T & V underestimates the substantial efforts of voluntary agencies and farmers in research and dissemination.

## *Feedback*

The clear lines of communication between extension and research incorporated in T & V are not adequate to ensure sufficient feedback. Feedback is inhibited by two sets of factors. First, as previously mentioned, T & V underrates the initiatives taken by farmers and voluntary organizations, especially if they fall outside its narrow definition of technology. Second, the support of T & V by donors has placed a premium on *positive* feedback. This has reinforced the acceptance by researchers of favourable accounts from field staff as well as strengthened their spurning of reports of partial adoption or rejection of technologies by farmers (Moore 1984; Sutherland 1987). The weakness of feedback on negative field experiences encouraged one observer to suggest that performance incentives be introduced that are linked to the reporting of negative experiences (Howell 1988).

## *Conclusion*

Overall, the principles of T & V strongly support central-source, technology-transfer thinking. Efforts have been made to enhance feedback and farmers' demand–pull on the research agenda by linking T & V with approaches to farming systems research (Sutherland 1987). In practice, however, these efforts have achieved only limited success. By its over-formalization of extension services, T & V is an irrelevant response to

- increasing financial stringency in the public sector of many developing countries,
- the needs and opportunities of small farmers in remote areas, who are the most difficult and costly to reach, and
- the need to stimulate local innovative capacity and discover how best to support it through links with formal research services.

# *Appendix 1*

# *Typology of Social Science Literature on Agricultural Research*

The literature surveyed in this review has been categorized into 24 major themes of social science studies. Most of the themes are self explanatory. Some material falls in several different places because it covers a range of subjects. The typology follows more or less the same themes used in the text. Although it is difficult to sort material in this way, we expect that this classification will be useful to readers who want to follow up research in different areas of analysis.

| Theme no. | Description |
|---|---|
| 1 | Diffusion, adoption, and constraints |
| 2 | Socioeconomic consequences and impact |
| 3 | Allocation of resources in agricultural research and extension programs |
| 4 | Productivity of agricultural research |
| 5 | Planning and policy analysis (ex-ante) in national agricultural research systems |
| 6 | Technology generation: theories of processes and diffusion |
| 7 | International transfer of agricultural technology |
| 8 | Technology generation and diffusion: institutions |
| 9 | Organization and management of national agricultural research systems |
| 10 | Communications and linkages in research and extension systems (including networks) |
| 11 | Motivation and behaviour of scientists |
| 12 | Farming systems and on-farm research |
| 13 | Public-sector international agricultural research: policy and planning (including environmental issues) |
| 14 | Indigenous technical knowledge and informal R & D processes |
| 15 | User-group analysis (including gender issues) |
| 16 | NGO technology generation and diffusion |
| 17 | New rural institutions: research for their development (including action research) |

| | |
|---|---|
| 18 | Technology development and diffusion in the private sector |
| 19 | Social scientists in agricultural research and extension |
| 20 | Potential contribution of social scientists to agricultural research |
| 21 | Artisans and small-scale rural industry and services |
| 22 | Seed multiplication and distribution |
| 23 | Property rights, community resource use, and genetic diversity |
| 24 | Agricultural extension |

Entries followed by an asterisk (*) contain either a collection of articles or reviews of the literature in that theme.

## *Theme 1. Diffusion, adoption, and constraints*

Agarwal 1983
Ahmed 1975
Barker et al. 1975*
Bunting and Curtis 1968
Byerlee 1988
Byrnes 1982*
Clay 1975, 1980
Dalrymple 1979*, 1986a*,b*,c*
Duff 1987
Evenson 1974
Farmer 1979
Feder and O'Mara 1981
Gerhart 1975
Hargrove 1978
ICRISAT 1979
IRRI 1977*, 1978a*, 1979*
Kenmore 1987
Kinsey and Ahmed 1983, 1984
Merrill-Sands 1986b*
Perrin and Winkelmann 1976*
Rogers 1976*, 1983*
Rundquist 1980
Ruttan 1982*, 1988*
Starkey 1987, 1988*

## *Theme 2. Socioeconomic consequences and impact*

Anderson et al. 1982*
Anderson et al. 1987*
Anderson et al. 1988
Anderson and Huber 1988
Bell 1972
Binswanger 1978a*
Blyn 1983
Burmeister 1987, 1988
Byers and Crow 1988
Byres 1972*
Carney 1988
Clay 1975
Cleaver 1972*
Collier et al. 1974
Collier et al. 1984
Dasgupta 1977*
Falcon 1970*
Farmer 1977*
Farrington 1986
Feder 1976, 1977
George 1976
Gill 1983
Glaeser 1987
Gotsch 1972
Greeley 1983, 1986
Griffin 1974*
Harriss 1979, 1987
Harriss and Harriss 1984
Hartman and Boyce 1979
Hawkes 1985
Hewitt de Alcantara 1972/73, 1976
Hightower 1976
Horton 1988a
Hossain 1988
IRRI 1978a*, 1986*
Jennings 1988
Jose 1984*
Kenmore 1987
Koppel and Ousa 1987
Ladejinsky 1977a,b
Lingard 1984
Lipton 1978*
Lipton and Longhurst 1985*
McInerney and Donaldson 1975
Pearse 1980*
Perelman 1976

Pinstrup-Andersen and Hazell 1985
Rudra 1987
Ruttan and Binswanger 1978*
Schmitz and Seckler 1970
Smale 1987
Stavis 1974
Timmer 1984
Wharton 1969*
Wisner 1977
Yudelman et al. 1972*

## *Theme 3. Allocation of resources in agricultural research and extension programs: history*

Anderson et al. 1982*
Anderson et al. 1990
Arndt et al. 1977*
Boyce and Evenson 1975*
Donaldson and McInerney 1973
Evenson 1981
Fishel 1971*
Judd et al. 1986
Lele and Goldsmith 1986
Mukhopadhyay 1988
Oram 1978*, 1985*
Oram and Vishva 1981*
Pandey and Roseboom 1989
Pariser and Wallerstein 1980
Pingali et al. 1987*
Pinstrup-Andersen 1982
Pray 1979
Schuh and Tollini 1979*
Wood 1980
Yadav 1987

## *Theme 4. Productivity of agricultural research*

Arndt et al. 1977*
Bal and Kahlon 1977
Bell 1986
Bennell and Thorpe 1987
Binswanger 1986a
Evenson 1978
Evenson and Kislev 1975*
Griliches 1958, 1964
Huffman and Miranowski 1981
Jha 1977
Khan and Akbari 1986
Lindner and Jarrett 1978
Lund et al. 1980
Martinez and Sain 1983
Minnesota Agricultural Experiment Station 1981*
Murphy and Sprey 1982
Nickel 1988
Norton and Davis 1981*
Pray 1979
Ruttan 1982*
Schmitz and Seckler 1970
Schuh and Tollini 1979*
Scobie 1979*
Sukhatme 1976
Wennergen and Whitaker 1977
Wise 1976, 1978, 1981
Wise and Fell 1980
Zahid and Mujahid-Mukhtan 1989

## *Theme 5. Planning and policy analysis (ex-ante) in national agricultural research systems*

ACC and IFPRI 1984
Acharya 1986
Anderson and Hazell 1989
Anderson and Parton 1983
Arndt et al. 1977*
BARC 1979
Barker 1981
Bell and Johnson 1986
Biggs 1978
Binswanger 1986, 1988
Binswanger and Ryan 1977
Boyce and Evenson 1975
Brandt and Goodwin 1980
Byerlee et al. 1987
Chambers 1978, 1983
Chandler 1979
Chaparro et al. 1981
Contant and Bottomley 1988
Dahlberg 1986
Daniels 1987
Daniels and Nestel 1981
Davis et al. 1987

de Janvry 1979
Elz 1984
Evenson 1981
Evenson et al. 1978
Fishel 1971*
Francis 1985
Harriss 1979, 1987
Harvey 1988
Hayami 1982
Herdt 1987
Horton and Prain 1987
Hulse and Pearson 1980
ICAR 1988
Jequier 1976
Jodha 1987
Joy 1978*
Kieft 1990
Klepper 1980b
Krishnamoorthy 1982
Lassen 1980
Lipton and Longhurst 1985*
Marcotte and Swanson 1987
McDowell 1988
McInerney 1978
McLean 1988b
Mellor 1977
Molnar 1989
NAS 1976
Neeley et al. 1979
Nestel 1989
Norton et al. 1981
Norton and Pardey 1987
Oram 1978, 1985
Oram and Paulino 1978
Pachico et al. 1987
Pardey and Norton 1988
Pearce and Turner 1990
Pingali et al. 1987
Pinstrup-Andersen 1980,1987
Pinstrup-Andersen et al. 1975
Pinstrup-Andersen et al. 1976
Pinstrup-Andersen and Byrnes 1975*
Pinstrup-Andersen and Caicedo 1978
Pinstrup-Andersen and Franklin 1977
Prinsley 1990
Ramalho de Castro and Schuh 1977
Raman 1989
Ryan 1984
Ryan et al. 1975
Schuh 1986
Schuh and Tollini 1979*
Shumway 1973, 1977, 1981
Scobie 1979*
Stocking 1981
Swaminathan 1988
Thompson and Warburton 1985
Ulbricht 1979
Valdes et al. 1979*
Vishnumurthy 1988
Wise 1975
Wolf 1986
Zuleta 1986

## *Theme 6. Technology generation: theories of processes and diffusion*

Ahmed and Ruttan 1988*
Anderson 1981
Anderson et al. 1990
Beckford 1984
Bell 1979, 1984, 1986
Bell et al. 1982
Biggs 1981a, 1986, 1989a
Biggs and Clay 1981, 1988
Binswanger 1978b*, 1986a
Binswanger and Ruttan 1978*
Blaikie 1983, 1989
Blaikie and Brookfield 1987
Boserup 1981
Burmeister 1987, 1988
Carr 1985
Clark 1985, 1987
Clark and Clay 1986
Clay 1980, 1982
de Janvry 1977
de Janvry and Dethier 1985
Evenson 1981
Evenson and Kislev 1975*
Frank 1981*
Franke and Chasin 1980
Gamser 1988
Geertz 1963
Grabowski 1988
Griffin 1974
Hadwiger and Browne 1987
Hayami and Kikuchi 1981
Hayami and Ruttan 1971*
Jennings 1988
Jequier 1976*
Klepper 1980a
Khun 1970*, 1977*
Koppel and Oasa 1987
Nandy 1988
Passmore 1978

Pineiro et al. 1979
Pingali et al. 1987
Popper 1959
Redclift 1987
Richards 1985, 1986
Rogers 1976*, 1983*
Rudra 1987
Ruttan 1975a, 1978, 1982, 1988b
Ruttan and Hayami 1984
Schultz 1979
Scobie 1979*
Thirtle and Ruttan 1987
Timmer 1980
van den Bosch 1980
Whyte 1981
Zandstra et al. 1979

## *Theme 7. International transfer of agricultural technology*

Anderson et al. 1987
Anderson et al. 1990
Anthony 1988
Bingen et al. 1988*
Binswanger and Ruttan 1978*
Burbach and Flynn 1980*
Burch 1980
Clark and Clay 1986
Dalrymple 1986a,b,c
Duff 1987
Fox 1987
Frank 1981*
Gamser 1988
Hopper 1978
Jenkins and West 1985
Kenmore 1987
McInerney and Donaldson 1975
Myrdal 1974*
NAS 1975
Norris 1982
Oldham 1987
Plucknett et al. 1987
Repetto 1985
Ruttan 1975a*,b*, 1978*, 1982*
Ruttan and Hayami 1973
Scobie 1979
Thomas 1975
Thrupp 1987
Tiffin et al. 1987
Timmer 1975, 1984
van den Bosch 1980

## *Theme 8. Institutions for technology generation and diffusion*

Ahmed and Ruttan 1988*
Anderson et al. 1982
Anthony et al. 1979
Arndt et al. 1977
Arnold 1976
Aurora and Morehouse 1974
Avila et al. 1989[a]
Basu 1979
Biggs 1980b, 1981a, 1982, 1983b, 1989a,b
Biggs et al. 1978
Biggs and Clay 1981, 1988
Brass 1982
Bredahl et al. 1980
Busch 1988
Clark 1980a
Clark and Clay 1986
Clay 1982
Coulter and Farrington 1988
Cuellar 1987[a]
Darling 1976
Dharampal 1983a,b
Dorling 1988
Drilon 1977
Evenson 1978
Ewell 1988*, 1989*
Farrington and Mathema 1990
Faye and Bingen 1989[a]
Fitzgerald 1981
Gaikwad et al. 1977
Gupta 1987b
Harrison et al. 1988
Hart 1961
Harvey et al. 1979
Hewitt de Alcantara 1972/3, 1976
Hightower 1976
Holtermann 1979
Horton 1986
Howell 1981
Hunter 1969
ICAR 1978
Idachaba 1980

Irvine et al. 1985
Jabbar and Abedin 1989[a]
Jahnke et al. 1987
James 1989a*,b
Jennings 1988
Kayastha et al. 1989[a]
Kean and Singogo 1988
Klepper 1980a
Lele and Goldsmith 1986
Luu 1988
McCalla 1978
Merrill-Sands et al. 1989
Merrill-Sands and McAllister 1988
Minnesota Agricultural Experiment Station 1981*
Morehouse 1971, 1980
Pain 1981, 1986
Pineiro et al. 1979
Pray 1981
Redclift 1983
Ruano and Fumigalli 1988[a]
Rundquist 1980
Rybczynski 1980
Scheidegger et al. 1989
Schuh 1986
Sigurdson 1978
Soliz et al. 1989[a]
Starkey 1988
Stavis 1978, 1979
Trigo and Pineiro 1981
Uchendu and Anthony 1975
Zandstra et al. 1979
Zulberti et al. 1979

[a] OFCOR Case Study of ISNAR. They are listed in this theme; however, their wide-ranging content also makes them relevant to other themes

## *Theme 9. Organization and management of national agricultural research systems*

Arnon 1975, 1989
Bengtsson and Tedla 1980*
Biggs 1981a, 1982, 1983a,b, 1989a
Bunting 1979
Chambers and Jiggins 1987a,b
Chandler 1979
Clark 1980a
Collinson 1988
Dahlberg 1986
Douglas 1980
Eicher 1988
Evenson 1978
Fishel 1971*
Freeman et al. 1974
Gupta 1987b, 1988, 1989b
Heaver 1985
Herrera 1977
Hesser et al. 1974
Hill 1964
ISNAR 1980, 1984, 1985, 1986, 1988
Leonard 1987
Madamba 1976
Mann and McPherson 1980
Marcotte and Swanson 1987
McLean 1988a*,c*
Merrill-Sands et al. 1986
Moock 1988
Moseman et al. 1980
Ngoc 1981
Nickel 1988
OECD 1970
Raman et al. 1988
Sachdeva 1987
Seckler 1987
Timmer 1980
Trigo 1986
Valdes et al. 1979*
Vyas and Kulkani 1977
Zulberti et al. 1979

## *Theme 10. Communications and linkages in research and extension systems (including networks)*

ADAB (various years)
ADC and IRRI 1980
Beale et al. 1986
Cernea et al. 1985*
Daniels 1987
Daniels and Nestel 1981
FSSP 1987
IDRC 1986
Kaimowitz 1990*[a]
Keya et al. 1987

Koenig 1987
Mackay 1980
Rogers 1976*, 1983*
Roling 1986, 1988, 1989
Sims and Leonard 1989*
Snyder 1986
Swanson 1975, 1976
Timmer 1980

[a] This book provides edited versions of many of the papers commissioned under the ISNAR Research Extension Linkages study.

## *Theme 11. Motivation and behaviour of scientists*

Aronowitz 1988
Bennell and Thorpe 1987
Beveridge 1957*
Binswanger 1978b*
Brammer 1980
Chambers 1980
Feyerabend 1988
Gadgil 1987
Ghildyal 1984
Gupta 1987a
Gupta et al. 1987
Hargrove 1977, 1978
IIM 1988
Irvine et al. 1985
Ladd 1979*, 1987*
Latour 1987
Latour and Woolgar 1979
Nickel 1988
Richards 1989*
Yadav 1987

## *Theme 12. Farming systems and on-farm research*

Abel et al. 1989
Agarwal 1978
Amanor 1989*
Anderson 1985
Ashby 1984, 1986, 1987
Ashby et al. 1987
Baker et al. 1988
Banta 1982
BARC 1975, 1981
Beavers 1978
Biggs 1980a,b, 1981b, 1982, 1983b, 1984
Binswanger et al. 1976
Binswanger et al. 1980
Binswanger and Pingali 1987
Birgegard and Fones-Sundell 1986
Box 1987
Brammer 1979
Buhr and Galt 1986
Byerlee 1987
Byerlee et al. 1979
Byerlee et al. 1982
Byerlee and Collinson 1980*
Chambers 1990
Chambers et al. 1989*
Chambers and Ghildyal 1985
Chambers and Jiggins 1987ab
CIMMYT 1979, 1984, 1988
CIP 1980, 1981a,b,c,d
Collinson 1979, 1981, 1982, 1986, 1988
Conway 1986a,b
Darling 1987
Davison and Martin 1965*
de Boer and Amir 1987
De Datta et al. 1978
de Janvry 1979
Dent and Thornton 1988
East Pakistan 1967
Ewell 1987
Farouk and Molla 1975
Farrington 1988
Farrington and Martin 1987*, 1988*
Feldman n.d.
Fernandez and Salvatierra 1986
Galt 1988
Galt and Mathema 1987
Ghildyal 1984
Gibbon 1981, 1985, 1987
Gilbert et al. 1980*
Gostyla and Whyte 1980
Grandin 1988
Greeley 1986
Greenwood 1980
Grosvenor-Alsop 1986, 1988
Grosvenor-Alsop and Sharma 1987
Harwood 1979
Heinemann and Biggs 1984
Hildebrand 1978, 1981
Hildebrand and Poey 1985
Hoque 1984
Horton 1984
Horton and Prain 1990

IIED 1989a,b
ILEIA 1989
IRRI 1984
Jones and Wallace 1986
Kean 1986, 1988
Kenmore 1987
Ker 1973
Khon Kaen University 1987
Kinsey 1980
Kirby et al. 1980
Knipscheer and Suradisastra 1986
Krishnamoorthy 1982
Kumar 1987
Kuyper 1987
Lightfoot 1987
Lightfoot et al. 1988
Longhurst 1981
Low 1986, 1988
Marcotte and Swanson 1987
Martin and Farrington 1987
Martinez and Sain 1983
Matlon et al. 1984
Maurya 1986
Maurya et al. 1988
Maxwell 1980, 1986a,b
Merrill-Sands 1986a
Molnar 1989
Norman 1974, 1980
Norman et al. 1982
Norman et al. 1988
Pandey et al. 1986
Patil 1987
Perrin and Winkelmann 1976
Poats et al. 1986
Poats et al. 1988
Pray et al. 1979
Remenyi 1985
Rhoades 1982, 1985, 1987
Rhoades et al. 1986
Rhoades and Booth 1982
Shaner et al. 1982
Simmonds 1985
Soliz et al. 1987a
Sperling 1988
Sumberg and Okali 1988
Sutherland 1986
TAC 1978
Tait and Napompeth 1987
Tripp 1982a,b, 1989
Tripp and Woolley 1989
Valdes et al. 1979*
Vyas and Kulkarni 1977
Waters-Bayer 1989
Werge 1978
Whyte 1981*
Yunus 1977
Yunus and Latifee 1975

## *Theme 13. Public-sector international agricultural research: policy and planning (including environmental issues)*

Barker et al. 1985
Baum 1986
Bengtsson 1977
Bengtsson and Tedla 1980
Blaikie 1983, 1989
Blaikie and Brookfield 1987
Buhr and Galt 1986
Busch and Sachs 1981
Buttle 1983
CGIAR 1980
Clark 1989
Dahlberg 1979*
Davis and Schirmer 1987
Dembo et al. 1987
Eckeholm 1976
Elkington 1985
Farrington 1989
Fleury 1980
Fowler et al. 1988a,b
Franke and Chasin 1980
Frankel and Soule 1981
Geevan 1984
George 1976
Goering 1979*
Groosman 1987a,b
Hacking 1986
Hamann 1987
Hatley and Thompson 1985
Heden 1979
Herdt 1987
Hobblelink 1987, 1988
Horton 1981, 1986
Hulse 1985*
Hutton 1978
IRRI 1978b
ISNAR and IADS 1982
IUCN 1980
Joffe and Greeley 1987
Johnson and Blake 1980
Johnstone 1988

Juma 1987, 1988
Junne 1987
Kaufmann and Cook 1982
Kenney 1987
Keya et al. 1987
Kloppenberg and Kleinman 1987a,b
Koenig 1987
Lipton 1988
Lipton and Longhurst 1989
McCormick 1989
Mellor 1987, 1988
Miller and Ford 1988
Mooney 1979, 1983, 1985
Morehouse and Sigurdsson 1977
NAS 1972, 1979, 1980
*Nature* 1980
Neeley 1989
Nishikawa 1989
ODI 1988
O'Riordan 1981
Pearce and Turner
Plucknett et al. 1987*
Prescott-Allen and Prescott-Allen 1988
Redclift 1984, 1987
Repetto 1986
Repetto and Gillis 1988
Ruckelshaus 1989
Ruivenkamp 1987
Ruttan 1978, 1982, 1986, 1987, 1989
Sanders 1988
Schmid 1985
Schuh and Tollini 1979*
*Scientific American* 1989
Scobie 1979*
Shah 1982
Sun 1986
TAC 1987
Thompson and Warburton 1985
Wade 1975
WCED 1987
Williams 1988
World Bank 1981*, 1987*
WRI and IIED 1986

## *Theme 14. Indigenous technical knowledge and informal R & D processes*

Ahmed and Coward 1977
Appu 1974
Basant 1987, 1988
Bell 1979
Belshaw 1979
Biggs 1980a,c
Biggs and Clay 1981
Brammer 1979, 1980
Brokensha et al. 1980*
Chambers and Howes 1979*
Clay 1975, 1980
Clay et al. 1978
Dharampal 1983a,b
Dommen 1975
Fortmann 1981
Gamser 1987
Green 1987
Hatch 1981
Haynes 1989
Jodha 1980
Lightfoot 1987
Macpherson and Jackson 1975
Maurya et al. 1987
Muller 1980
Murray 1980
Nandy 1977
Norman 1974
Rhoades 1985, 1987
Richards 1979, 1985, 1986
Samson 1969
Sumberg and Okali 1988
Tait and Napompeth 1987
Verma and Singh 1969
Warren et al. 1990*
Wright 1985

## *Theme 15. User-group analysis (including gender issues)*

Ahmed 1985
Ashby 1984
Biggs and Groavenor-Alsop 1984
Boserup and Liljencrantz 1975
Bruce 1980
Carney 1988
Collinson 1981
Dey 1981
Dixon 1980
Gamser 1988

Germain 1976
Grandin 1988
Greeley 1986
Grosvenor-Alsop 1988
Grosvenor-Alsop and Sharma 1987
Gupta 1987b
Gupta et al. 1986
Howell 1981
Jiggins 1986c
Kalkar 1985
Lewis 1981
Mazumdar 1988
Melrose 1982
Moock 1986*
Muntemba 1982
Norman et al. 1988
Poats et al. 1988*
Rockefeller Foundation and ISNAR 1985a*,b*
Scheidegger et al. 1989
Swaminathan 1985
Wahyumi et al. 1987
Whitehead 1985
Yudelman 1987
Zeidenstein 1979, 1980

## *Theme 16. NGO technology generation and diffusion*

BARC 1975
Barnes 1986
Bebbington 1989
Biggs and Griffith 1987
Biggs and Senaratne 1986
BRAC 1983a,b
Bunch 1985, 1987
Carr 1981, 1985
Choudhury 1989
Drabek 1987
Farrington and Biggs 1990*
Gilbert 1990
Gutierrez 1988
Henderson 1990
Justice 1989
Korten 1987
Osborn 1990
Oxby 1989
Thiele et al. 1988
Wellard et al. 1990*
Whitby 1987
Wilson 1985
Yudelman 1987

## *Theme 17. New rural institutions: research for their development (including action research)*

Castillo 1972
Conway 1986a,b
Farrington and Biggs 1990*
Fernandez 1986
Gamser 1987
Ker 1979
Khan 1979
Korten 1980
Kuyper 1987
Levine and Hart 1981
Palmer-Jones and Mandal 1987
Pati 1987
Redclift 1983
Uphoff 1986, 1987
Whyte and Boynton 1983
Wood 1984
Wood and Palmer-Jones 1990

## *Theme 18. Technology development and diffusion in the private sector*

Agribusiness Council 1975
Carr 1981
Chancellor 1986
Chuta and Leidholm 1979, 1984
Dinham and Hines 1982
Evenson et al. 1987
Feder 1977, 1979
Fowler et al. 1988a,b
Goldsmith 1985
Groosman 1987a,b
Groosman et al. 1988
Jacoby 1975
Jenkins and West 1985
Juma 1987, 1988
Liedholm and Mead 1987
Pray 1983

Pray et al. 1989
Pray and Echeverria 1988, 1989
Ruigu 1988
Ruivenkamp 1987
Ruttan and Pray 1987
Tait and Clayden 1984
Tait and Hughes 1984
Tait and Napompeth 1987
Tiffin et al. 1987
Wattanutchariya 1983
Wilkes 1987

## *Theme 19. Social scientists in agricultural research and extension*

Anderson 1985
Bingen and Poats 1990
Bonnen and Johnson 1988
Byerlee et al. 1979
Byerlee and Ali 1985
Byerlee and Tripp 1988
Busch 1981
Busch and Lacey 1983
Cernea 1985*
Cernea and Guggenheim 1985
Feder 1977, 1979
Fowler et al. 1988a,b
Goldsmith 1985
Groenfeldt and Moock 1989*
Hill 1982, 1986
Horton 1984
Jacoby 1975
Jones and Wallace 1986
Maxwell 1986a
McCorkle 1989
Rhoades 1982
Rhoades et al. 1986
Sutherland 1987
Swanson 1976
Werge 1978
Whyte and Boynton 1983
Wilkes 1987

## *Theme 20. Potential contribution of social scientists to agricultural research*

Bebbington 1989
Bennett 1986
Bingen and Poats 1990
Byerlee and Ali 1985
Cernea 1985
Chambers 1983
Chambers and Jiggings 1987a*,b*
FSSP 1987
Gibbon 1985
Groenfeldt and Moock 1989*
Gupta 1989b
Hardin 1981*
Horton 1984, 1988b
Junne 1987
Maxwell 1986b
Rhoades 1982
Rhoades and Booth 1982
Rhoades et al. 1986*
Roling 1986
Ruttan 1982, 1988b
Sanders 1988
Sutherland 1987
Swanson 1976
Werge 1978*
Wessel and Meltrick 1986
Zuleta 1986

## *Theme 21. Artisans and small-scale rural industry and services*

Basant 1987*, 1988*
Basu 1979
Bockhop et al. 1986
Broehl 1986
Carr 1981, 1985
Cernea 1985
Chambers 1983
Chuta and Liedholm 1979, 1984
Dixon 1980
Harrison et al. 1988
Jabbar 1985
Jain 1986
James 1989a*
Kinsey and Ahmed 1983, 1984

Liedholm and Mead 1987
Ruttan 1988b
Sanders 1988
Sigurdson 1978
Sims et al. 1988
Whitby 1987

### *Theme 22. Seed multiplication and distribution*

Douglas 1980
Green 1987
Groosman 1987a*,b*
Groosman et al. 1988
Henderson 1990
Maurya et al. 1988
Osborn 1990
Ruigu 1988
Singh and Sayre 1985

### *Theme 23. Property rights, community resource use, and genetic diversity*

Fleury 1980
Friis-Hansen 1988
Gamser 1987
Godden 1987
Goodell 1984a,b
Groosman 1987b
Gupta 1989a
Hart 1979
Hatley and Thompson 1985
Hawkes 1983
Jodha 1987
Juma 1987*, 1988*
Kenney 1987
Keya et al. 1987
Kloppenberg and Kleinmann 1987a,b
Koenig 1987
Livingston 1986
Martin and Yoder 1987
Mooney 1979, 1983, 1985
Oldfield and Alcorn 1987
Pillar and Yamamoto 1988
Prescott-Allen and Prescott-Allen 1988
Ruivenkamp 1987
Schmid 1985
Shah 1982
Stallman and Smid 1987
Sun 1986
Wade 1988
Warford 1987
Williams 1988
Wisner 1977
Wolf 1985
Wood 1984
Wood and Palmer-Jones 1990*

### *Theme 24. Agricultural extension*

Axinn 1987
Baxter et al. 1988
Benor and Baxter 1984
Benor and Harrison 1977
Ewell 1989*
Feder et al. 1985
Feder et al. 1987
Francis and Rawlins-Branan 1987
FSSP 1987
Gamser and Jones 1987
Howell 1982*, 1988*
Jones 1986
Kaimowitz 1990*
Moore 1984
Pandey and Cromwell 1989
Rivera and Schram 1987*
Sagar and Farrington 1988
Swanson 1975, 1976

# *Appendix 2*

## *Acronyms and Abbreviations*

| | |
|---|---|
| **ACC** | Administrative Committee on Coordination (New York, NY, USA) |
| **ADAB** | Agricultural Development Agencies in Bangladesh (Dhaka, Bangladesh) |
| **ADC** | Agricultural Development Council (New York, NY, USA) |
| **ATI** | Appropriate Technology International (Washington, DC, USA) |
| **BARC** | Bangladesh Agricultural Research Council (Dhaka, Bangladesh) |
| **BRAC** | Bangladesh Rural Advancement Committee (Dhaka, Bangladesh) |
| **BRRI** | Bangladesh Rice Research Institute (Dhaka, Bangladesh) |
| **CGIAR** | Consultative Group on International Agricultural Research (Washington, DC, USA) |
| **CIAT** | International Center for Tropical Agriculture (Cali, Colombia) |
| **CIMMYT** | International Centre for Maize and Wheat Improvement (Mexico City, Mexico) |
| **CIP** | International Potato Center (Lima, Peru) |
| **CIRAD** | Centre de cooperation internationale en recherche agronomique pour le developpement (Paris, France) |
| **FAO** | Food and Agriculture Organization of the United Nations (Rome, Italy) |
| **FSR** | farming systems research |
| **FSSP** | Farming Systems Support Project (University of Florida, Gainesville, FL, USA) |
| **HYV** | high-yielding variety |
| **IAC** | International Agricultural Centre (Wageningen, Netherlands) |
| **IADS** | International Agricultural Development Service (New York, NY, USA) |
| **IARCs** | international agricultural research centres (affiliated to CGIAR) |
| **ICAR** | Indian Council of Agricultural Research (New Delhi, India) |

| | |
|---|---|
| **ICRISAT** | International Crops Research Institute for the Semi-Arid Tropics (Hyderabad, India) |
| **IDRC** | International Development Research Centre (Ottawa, Canada) |
| **IFPRI** | International Food Policy Research Institute (Washington, DC, USA) |
| **IIED** | International Institute for Environment and Development (London, UK) |
| **IIM** | Indian Institute of Management (Ahmedabad, India) |
| **ILEIA** | Information Centre for Low External Input Agriculture (Leusden, Netherlands) |
| **IRRI** | International Rice Research Institute (Los Baños, Philippines) |
| **ISNAR** | International Service for National Agricultural Research (The Hague, Netherlands) |
| **IUCN** | International Union for the Conservation of Nature and Natural Resources (Morges, Switzerland) |
| **LGC** | land-grant college |
| **MNC** | multinational corporation |
| **NAS** | National Academy of Sciences (Washington, DC, USA) |
| **NGO** | nongovernmental organization |
| **ODI** | Overseas Development Institute (London, UK) |
| **ODNRI** | Overseas Development Natural Resources Institute (London, UK) |
| **OFCOR** | on-farm client-oriented research program (ISNAR) |
| **OECD** | Organisation for Economic Cooperation and Development (Paris, France) |
| **R & D** | research and development |
| **SSAAR** | social science analysis of agricultural research |
| **T & V** | Training and Visit extension system |
| **TAC** | Technical Advisory Committee (CGIAR, Washington, DC, USA) |
| **UEA** | University of East Anglia (Norwich, UK) |
| **UNRISD** | United Nations Research Institute for Social Development (Geneva, Switzerland) |
| **UPWARD** | Asia-wide Network on the Users' Perspective with Agricultural Research and Development |
| **VSO** | Voluntary Service Overseas (London, UK) |
| **WCED** | World Commission on Environment and Development |
| **WRI** | World Resources Institute (Washington, DC, USA) |

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